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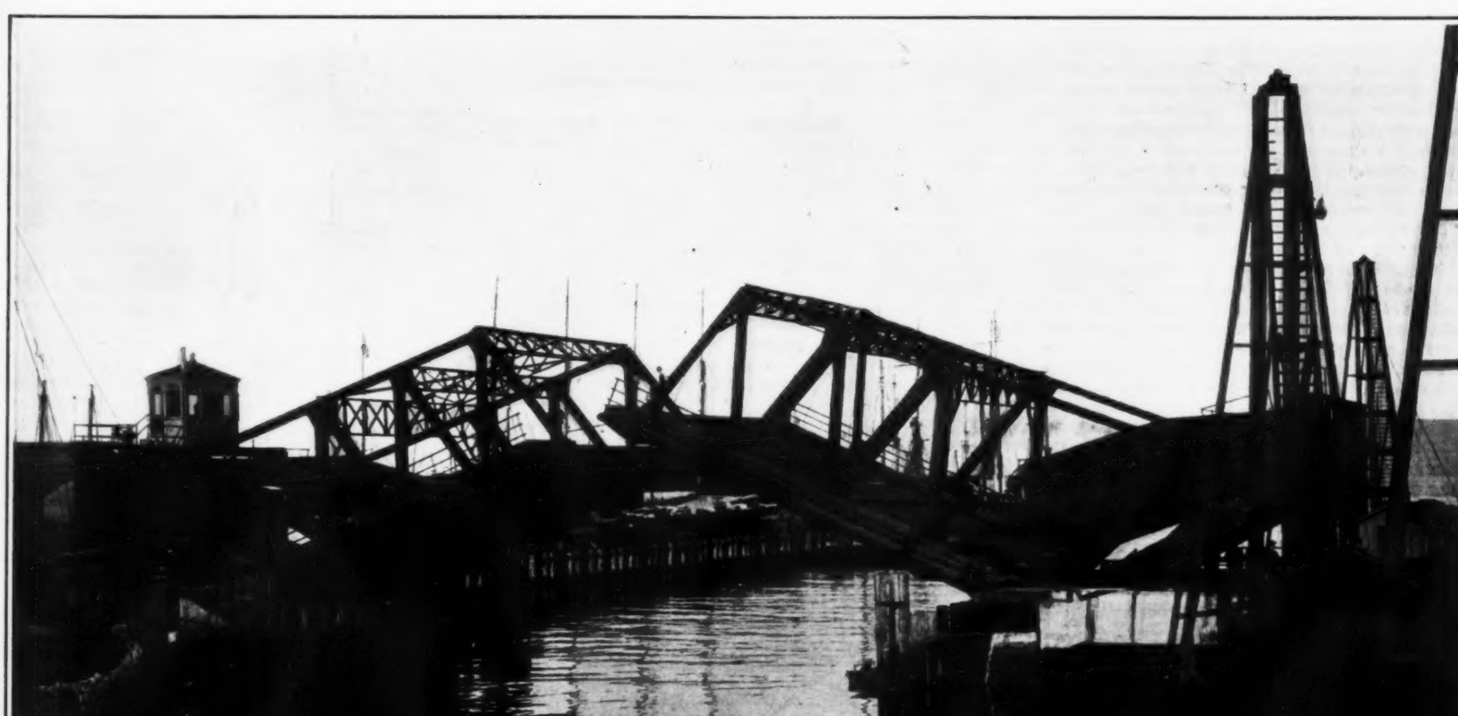
THE BASCULE BRIDGE OPEN.



THE BRIDGE ABOUT TO CLOSE.

NEW TYPE OF BASCULE BRIDGE.*

By Enos Brown.

In connection with certain important railroad improvements at San Francisco, it became necessary to build a special type of movable bridge across a navigable estuary in the center of the city, where the traffic was at all times greatly congested. After the consideration of many plans, it was decided to adopt a bridge of the Page bascule type, partly for the reason that the floor of the bridge was to be only five feet above high tide and necessitated the adoption of the "through" or "high truss" design.

The sub-structure construction was a task of peculiar difficulty owing to the character of the foundation, which consisted of mud deposits overlying a bed of clay and sand, and peculiarly liable to give way under heavy pressure. A Wakefield coffer dam was first put in, and the soft material dredged out; piles were then driven and cut off at about minus 37, and concrete filled in to minus 27.5 under water. The dam was pumped out, and the balance of the concrete added in the dry. Despite an interruption caused by a cave-in, the foundation was eventually completed. Subsequent and prolonged tests have established its complete stability.

The bridge has a roadway 36 feet in the clear, with an 8-foot sidewalk. From center to center of end posts the distance is 175 feet, center to center of trunnion 113 feet, with a clear channel of 75 feet, the crossing being at an angle of 77 degrees. The important feature in the design is that all movable parts are theoretically in balance during operation, the only power required being that to put the bridge in motion and overcome the effect of wind and friction.

The girders carrying the counterweight are mounted pivotally on pins near the tops of the vertical end posts, and the opposite ends of the girders rest on shafts, which carry the load to rollers running on the track girders. The main driving pinion is keyed to this shaft between the rollers, and engages with a rack running along the center of track girders. To the end of the roller shaft on the inside of the counterweight girder is attached the main driving gear, from which a train of gears leads down to the motor. The gearing and motors are supported on longitudinal girders, these being connected to cross girders, which are attached to the inside counterweight girders, and thus the machinery, motors, and girders supporting the same, act as counterweight. The balance of counterweight required on the inside girders is made up of concrete resting on buckle plates riveted to the machinery girders. The counterweight on the outside girders consists of cast-iron blocks bolted to the webs. As the counterweight is distributed, the load is practically equal on each of the rollers.

Each leaf of the bridge is operated by two 40-horsepower railway type motors, each pair being connected to a series parallel controller in the main operator's house, which is mounted above the roadway at the north end of the bridge. Connection is made with the motors on the south leaf through lead-covered iron-armored submarine cables laid in a trench across the channel. In order that the operator may know the position of each leaf of the bridge both day and night, an electric indicator is provided in the house, whereby this information is given to him by means of the lighting and extinguishing of a number of electric lamps.

Each motor is provided with a magnetic brake. The center lock is operated by means of a 3-horse-power inclosed type motor at the end of the north leaf. This motor is operated through a controller on the switchboard. The position of the center lock is shown to the operator by means of an indicator similar in design to that referred to above.

In the operator's house is a marble switchboard on which are mounted such instruments, circuit breakers, cut-outs, switches, etc., as are required in first-class installations of this sort. At the extremity of each of the leaves, and outside of the roadway, is mounted an electric lantern showing red to the river, in order to warn navigation when the bridge is closed, and to show the position of the point of the bridge when open.

While this bridge has been in operation only a comparatively short time, it has been fully demonstrated that the power provided in the motors is more than ample. Tests taken before the machinery and moving parts had time to wear into a "smooth" condition show that each leaf of the bridge requires approximately 35 horse-power to raise or lower, and the complete motion was performed in 24 seconds. This was with the motors running in multiple. With the motors connected in series, less than 20 horse-power was necessary, and the motion was performed in 45 seconds.

CONCRETE AGGREGATES.†

By Sanford E. Thompson, M.Am.Soc.C.E.

The term "aggregate" includes not only the stone, but also the sand which is mixed with cement to form either concrete or mortar; in other words, it is the entire inert mineral material. This definition, now generally accepted, has replaced the one restricting the term to the coarse aggregate alone.

It is the object of this paper to enumerate briefly the general principle which should be followed in the selection of sand and stone for mortar and concrete and to briefly describe the method of testing aggregates and determining proportions which the author has found to give good results in practice.

* Specially prepared for the Scientific American Supplement.

† Paper read before the Cement Users' Association.

At the outset it may be said that a concrete of fair quality, if rich enough in cement, can be made with nearly any kind of mineral aggregate, but there is nevertheless a wide variation in the results produced. For the fine aggregate, sand, broken stone screenings, pulverized slag, or the fine material from cinders may be used, separately, or in combination with each other. For the coarse aggregate, broken stone, gravel, screened gravel, slag, crushed lava, shells, broken brick, or mixtures of any of these may be employed. However, the very fact of the adaptability of concrete to so wide a range of materials—every one of which really consists of a large class varying in size, shape, and composition—tends to blind one to the economies which often may be effected and the improvement in quality which almost always will result by a careful selection and proportioning of the aggregates.

In many cases, especially where the cost of Portland cement is low, it may be cheaper to use whatever materials are nearest at hand, and insure the quality of the concrete or mortar by making it excessively rich in cement. If the structure is small and of little importance, this course is properly followed, but, on the other hand, if a large amount of concrete is to be laid, and especially if the process is to be carried on in a factory—as in concrete block manufacture—it pays from the standpoints of both quality and economy to use great care in the selection of the aggregates as well as of the cement and to provide means for maintaining uniformity.

To illustrate the variation which different aggregates may produce even when they are mixed with cement in the same proportions, the author has selected a few comparative tests of mortar and concrete.

Effect of Different Aggregates Upon the Strength of Mortar and Concrete.—Tests made by Mr. Rene Feret,* of France, with mortar made from different natural sands show a surprising variation in strength, which is evidently due simply to the fineness of the sand of which the different specimens are composed. Selecting from his results proportions 1 : 2.5 by weight, that is, 1 part cement to 2½ parts sand, and converting his results at the age of five months, from French units to pounds per square inch, the average tensile strength of Portland cement mortar made with coarse sand is 421 pounds per square inch, with medium sand 368 pounds per square inch, and with fine sand 302 pounds per square inch. In the crushing strength, usually the most important consideration, the difference is even more marked. In round numbers, at the age of five months, the mortar of coarse sand gave 5,000 pounds per square inch, the medium sand 3,400 pounds per square inch, and the fine sand 1,900 pounds per square inch. Note that the different sands were not artificially prepared, but were taken from the natural bank, and correspond to those which every day are being used for concrete and mortar.

The effect of different mixtures of the same kind of material is shown by tests with which the author has been connected during the past year, but the results of which have not yet been published. By varying the sizes of the particles of the aggregates, but using in all cases stone from the same ledge and the same proportion of cement to total aggregate by weight, namely 1:9 (or approximately 1:3:6), he found it possible to make specimens the resulting strengths of some of which were 2½ times the strengths of others.

The effect of the hardness or strength of the stone used for the coarse aggregate is shown in tests by George W. Rafter,† which, for proportions about 1:2:6.5, gave 50 per cent greater compressive strength of concrete where the coarse aggregate was a hard sandstone than, with similar proportions, where a shale was substituted. In some of his tests the harder stone gave a concrete even double the strength of the concrete with the softer stone.

General Principles for Selecting Stone.—The quality of concrete is affected by the hardness of the stone; the shape of the particles; the maximum size of the particles, and the relative sizes of the particles.

If broken stone is used, and there is an opportunity for choice, the best is that which is hard, with cubical fracture, with particles whose maximum size is as large as can be handled in the work, with the particles smaller than, say, one-fourth inch screened out (to be used as sand), and with the sizes of the remaining coarse stone varying from small to large, the coarsest predominating.

If gravel is used, it must be clean; the maximum size of particles should be as large as can be handled in the work; grains below say one-fourth inch should be screened out (to be used as sand), and the size of the stones should vary, with the coarsest predominating.

I have said that the size of the coarsest particles of stone should be as large as can be handled in the work. This is because the strength of the concrete is thereby increased, and a leaner mixture can be used than with small stone. In mass concrete the stones, if too large, are liable to separate from the mortar unless placed by hand or derrick, as in rubble concrete, and a practical maximum size is 2½ or 3 inches. In thin walls, floors, and other reinforced construction, a 1-inch maximum size is generally as large as can be easily worked between the steel. In some cases where the walls are very thin, say, 3 or 4 inches, a ¾-inch maximum size is more convenient to handle.

It is a little more trouble, but almost always best, to screen out the sand from gravel, or the fine material from crusher stone, and then remix it in the proportions required by the specifications, for, otherwise, the proportions will vary at different points, and one must use, and pay for an excess of cement to balance the lack of uniformity.

* See Taylor and Thompson's "Concrete, Plain and Reinforced," 1905, p. 136.

† Second Report on Genesee River Storage Project, 1894.

If gravel is used, it is absolutely essential that it shall be clean, because if clay or loam adheres to the particles, the adhesion of the cement will be destroyed or weakened. Tests of the Boston Transit Commission* gave an average unit transverse strength of 606 pounds per square inch for concrete made with clean gravel as against 446 pounds per square inch when made with dirty gravel.

Comparative Values of Different Stones.—Different stones of the same class vary so widely in texture and strength that it is impossible to give their exact comparative values for concrete. A comparison by the author of a large number of tests of concrete made with different kinds of stone indicates that the value of a broken stone for concrete is largely governed by the actual strength of the stone itself, the hardest stone producing the strongest concrete. This forms a valuable guide for comparing different stones. Comparative tests indicate that different stones for concrete in order of their value, are approximately as follows: (1) trap, (2) granite, (3) gravel, (4) marble, (5) limestone, (6) slag, (7) sandstone, (8) slate, (9) shale, (10) cinders. Although, as stated above, the wide differences in the quality of the stone of any class make accurate comparisons impossible—and this difficulty is increased by the fact that the proportions and age of the specimens affect their relative value—an approximate estimate drawn from actual tests, gives the value for concrete of good quality sandstone as not more than three-fourths the value of trap, and the value of slate as less than half that of trap. Good cinders nearly equal slate and shale in the strength of concrete made with them.

The hardness of the stone grows in importance with the age of the concrete. Thus gravel concrete, because of the rounded surfaces, at the age of one month may be weaker than a concrete made with comparatively soft broken stone, but at the age of one year it may surpass in strength the broken stone concrete because, as the cement becomes hard, there is greater tendency for the stones themselves to shear through, and the hardness of the gravel stones thus comes into play. Gravel makes a dense mixture, and if much cheaper than broken stone can usually be substituted for it.

A flat grained material packs less closely and generally is inferior to stone of cubical fracture.

General Principles for Selecting Sand.—The only characteristics of sand which need be considered are the coarseness and relative coarseness of its grains and its cleanness. These qualities affect the density of the mortar produced, and therefore the test of the volume of mortar, or "yield," determines which of two or more sands is best graded. The "yield" or "volumetric" test, I consider of greater value for quick results than all others put together. The methods of employing it are described farther along in the paper.

The best sand is that which produces the smallest volume of plastic mortar when mixed with cement in the required proportion by weight.

A high weight of sand and a corresponding low per cent of voids are indications of coarseness and good grading of particles; but because of the impossibility of establishing uniformity in weighing or measuring, they are merely general guides which cannot under any conditions be taken as positive indications of true relative values. The various characteristics of sands are separately considered in the following paragraphs:

Weight of Sand.—A heavy sand is generally denser, and, therefore, better than a light sand. However, this is not a positive sign of worth, because the difference in moisture may affect the weight by 20 per cent, and when weighed dry the results are not comparable for mortars, since a fine sand takes more water than coarse.

As an illustration of the variation in weight of natural sands having different moisture, the author found that the weight per cubic foot of Cowe Bay sand, which, dry, averaged 103 pounds, when placed out of doors, and weighed after a rain in exactly the same way (although it was allowed to drain for two days), averaged 83 pounds.

Voids in Sand.—The voids, like the weight, are so variable in the same sand, because of different percentages of moisture and different methods of handling, that their determination is of but slight value. In the Cowe Bay sand just mentioned, the voids were 38 per cent in the sand, dry, and 52 per cent in the same sand, moist.

Because of such discrepancies the author prefers to mix the sand with the cement and water, and determine the voids in the fresh mortar, as described later. This gives a true comparison of different sands, since with the same percentage of cement the mortar having the lowest air plus water voids, is the strongest.

Coarseness of Sand.—A coarse sand produces the densest, and, therefore, the strongest, mortar or concrete. A sufficient quantity of fine grains is valuable to grade down and reduce the size of the voids, but in ordinary natural material, either sand or screenings, there will be found sufficient fine material for ordinary proportions, such as 1 : 1, 1 : 2, or 1 : 2½. For leaner proportions, such as 1 : 4 or 1 : 5, and sometimes 1 : 3, an addition of fine particles will be found advantageous to assist the cement in filling the voids. A dirty sand, that is, one containing fine clay or other mineral matter, up to, say, 10 per cent, is actually

* Seventh Report of Boston Transit Commission, 1901, p. 30.

found by tests to be better than a clean sand for lean mortars.

For water-tight work it is probable that a larger proportion of very fine grains may be employed than for the best results in strength. This is a question, however, which has not yet been thoroughly investigated.

Feret's rule for sand to produce the densest mortar, is to proportion the coarse grains as double the fine, including the cement, with no grains of intermediate size. There is difficulty in an exact practical application of this rule, but it indicates the trend to be followed in seeking maximum density and strength.

Cleanness of Sand.—An excess of fine material or dirt, as has just been noted, weakens a mortar which is rich in cement. It may also seriously retard its setting. My attention was recently called to a concrete lining, one portion of which failed to set hard for several weeks, although the same cement was used as on adjacent portions of the work. The difficulty proved to be due entirely to the fact that the contractor substituted in this place a very fine sand, the regular material happening to run low.

Sharpness of Sand.—Notice that the quality of sharpness has not been mentioned among the essential characteristics of sand. This omission was intentional. The majority of specifications still call for "sharp" sand, and yet I have never known—and I venture to predict that none of those present have ever known—a sand to be rejected simply because of its lack of sharpness. As a matter of fact, if two sands have the same sized grains, and contain an equal amount of dust, the one with rounded grains is apt to give a denser and stronger mortar than the sharp-grained sand. A sand with a sharp "feel" is preferable to another, not to any extent because of its sharpness, but because the grittiness indicates a silicious sand, which is apt to have no excess of fine material.

Sand vs. Broken Stone Screenings.—Many comparative tests of sand and screenings have been made with contrary results. While frequently crusher screenings produce stronger mortar than ordinary sand, the author in an extensive series of tests has found the reverse to be true. This disagreement is probably due to the grading of the particles, although in certain cases the screenings may add to the strength because of hydraulicity of the dust when mixed with cement.

Testing Sand.—In the previous paragraphs are shown the defects in the more common methods of examining sand.

I now venture to propose a test for sand which I am using constantly in my experiments for clients. Tests which I made in 1903 proved to me the value of the principles of density of mortars laid down by Feret, and in the winter of that year similar plans for testing aggregates were introduced by Mr. William B. Fuller and myself at Jerome Park Reservoir, New York City. The object of the test is to determine which of two or more sands will produce the denser, and therefore the stronger, mortar, in any given proportions. From the results of test, the relative strengths of two different mortars can be approximately estimated without resorting to actual tensile or compressive tests.

In opening this paper I have given the different results in strength which Mr. Feret found with coarse, medium and fine sands respectively, these relative strengths in compression being, respectively, 5,200, 3,400, and 1,900 pounds, with proportions 1 : 2½ by weight in each case. An examination of the tests shows that the strongest mortar was produced with a given weight of aggregate.

The mortar with medium sand occupied a volume 7½ per cent in excess of the volume of the mortar with coarse sand, and the mortar of fine sand, a volume 17 per cent in excess of the mortar with coarse sand.

Following these principles, two sands may be compared and the better one selected by determining which produces the smaller volume of mortar with the given proportions by weight.

Using the method described below, the author has been able to increase the strength of a mortar about 40 per cent by merely changing the sizes of grains of the aggregate.

The method of making the test is as follows: If the proportions of the cement to sand are by volume, they must be reduced to weight proportions; for example, if a sand weighs 83 pounds per cubic foot moist, and the moisture found by drying a small sample of it at 212 deg. F. is 4 per cent, which corresponds to about 3 pounds in the cubic foot, the weight of dry sand in the cubic foot will be 83 — 3 = 80. If the proportions by volume are 1 : 3, that is, 1 cubic foot dry cement to 3 cubic feet of moist sand, and if we assume the weight of the cement as 100 pounds per cubic foot, the proportions by weight will be 100 pounds cement to 3 times 80, which equals 240 pounds sand, which corresponds to proportions 1 : 2.4 by weight.

A convenient measure for the mortar is a glass graduate, about 1½ inches diameter, graduated to 250 cubic centimeters. A convenient weight of cement, plus sand, for a test is 350 grammes. For weighing, I employed Harvard trip scales, which weigh with fair accuracy to one-tenth of a gramme. The sand is dried and mixed with cement in the calculated proportions in a shallow pan about 10 inches diameter and 1 inch deep. The mixing is conveniently done with a 4-inch pointing trowel. The dry mixed material is formed into a circle, as in mixing cement for briquettes, and sufficient water added to make a mortar of plastic consistency similar to that used in laying brick masonry. After mixing five minutes the mortar is introduced about 20 cubic centimeters at a time into the graduate, and, to expel any air bubbles, is lightly tamped with a round stick, with a flat end. The mortar is allowed to settle in the graduate for one or two hours, until the level becomes constant, when the surplus water is poured off, and the volume of the mortar in cubic centimeters is read. For greater exactness a correction may be introduced for mortar remaining on pan and trowel. The other sands which are to be compared with this one are then mixed with cement in the same proportions by dry weight, and sufficient water added to give the same consistency. The percentage of water required will vary with the different aggregates, the finer sand requiring the more water. After testing all the mortars, the sand which produces the strongest mortar is immediately located as that in the mortar of the lowest volume. By systematic trials, the best mixture of two or more sands may also be found.

In some cases a correction must be introduced for the specific gravity of the sand; for example, ordinary bank sand has an average specific gravity of 2.65, but if this is to be compared with broken stone screenings having a specific gravity of, say, 2.80, the proportions of the two must be made slightly different. For these particular specific gravities, proportions 1 : 3, by weight, with sand, correspond in absolute volume to proportions 1 : 3.2, by weight, of the screenings.

In making these tests, it is also important to notice the character of the mortar as it is being mixed. It should work smooth under the trowel and be practically free from air bubbles.

Calculating Relative Strength of Mortars.—From the results of the tests described, it is possible to very closely estimate the relative strength of different mortars made with the same cement. A formula is given by Mr. Feret* for calculating the strength from the absolute volumes of the ingredients of the mortar, but wishing to avoid the calculation of the absolute volumes and obtain the results directly from the weights of the materials and the volume of the mortar made from them, I have found it possible to evolve from Feret's formula one which makes use only of the data from the tests in the graduates above described. The formula is as follows: Let

P = compressive strength of mortar in pounds per square inch.

K = a constant.

Q = measured volume or quantity of mortar in cubic centimeters.

C = weight of cement used in grammes.

S = weight of sand used in grammes.

gc = specific gravity of cement.

gs = specific gravity of sand.

Then,

$$P = K\left(\frac{g_s}{g_c}\right)^2\left(\frac{C}{g_s\,Q\text{-}S}\right)^2$$

This formula may be readily altered to apply entirely to the English system of weights and measures.

The value of K varies with different cements and different ages of the same mortar, hence it is simplest to disregard the actual strength, and consider the relative strengths of any two or more mortars as in direct proportion to the values of the square of the quantities in brackets.

If the aggregates to be compared have similar specific gravity, as is the case with different natural sands, the relative strengths of the mortars will be in proportion to the values of

$$\left(\frac{C}{G_s\,Q\text{-}S}\right)^2$$

To illustrate the practical value of the formula, aside from theory, it may be of interest to refer to a recent series of comparative tests made in my own laboratory. A mixture of sand and cement in proportions 70 grammes cement to 276 grammes sand produced in a graduate, a volume of mortar of 178 cubic centimeters. After making a number of trial tests, using in every case the same proportions by weight, a new mixture of sizes of the same aggregate was obtained, whose volume, when mixed with the cement and water, was 165 cubic centimeters. The specific gravity of the sand, which in this instance was crushed rock, in both cases was 2.88. Substituting these values in the formula, we find the ratio of the two tests to be 1 to 1.40, that is, the mortar having the smallest volume ought to be 1.40 times (or 40 per cent) stronger than the other. Actual tests of the two mortars afterward made in similar proportions into long prisms, gave at the end of fourteen days an average of 832 pounds per square inch for one and 1,153 pounds per square inch for the other, thus showing an actual excess of strength of 39 per cent, which is substantially identical with the estimated increase.

Testing Concrete Aggregates.—For concrete in any given proportions, the best sizes of stone and of sand may be determined by similar methods to those described for testing sand mortars, although larger quantities of materials must be used and the measure must be strong enough to withstand the light ramming which is necessary. A short length of cast iron pipe, closed at one end, may be used for this.

The aggregates which mixed with cement in the required proportions produce the smallest volume of concrete, are usually the best, although, as already indicated, the shape of the particles and their hardness must also be taken into consideration.

Proportioning Concrete.—Lack of time forbids the description of the application of these methods to determining the relative proportions of two or more aggregates in a concrete. Here again we have the general principle that the weight of material and the percentage of cement remaining the same, the mixture producing the smallest volume of concrete is the best.

* See Taylor and Thompson's "Concrete, Plain and Reinforced," 1905, p. 139.

THE AUTOMOBILE IN WAR.

THE supremacy of France, from the automobile standpoint, has been recognized for some years, and it is generally agreed that French "touring artillery" has followed the progress of French guns.

It is understood, in principle, that the automobile will be utilized in France in case of mobilization, although nothing definite on this subject seems as yet to be decided upon, and it may be feared that an organization not yet completed in time of peace may be completed with difficulty on the day of the declaration of war. What will not have already been done at such moment will not be done later, and that is why it would be well to prepare now for the events of the morrow.

It is not in a few hours, in taking at hazard the first carriage that offers itself, that we obtain a touring vehicle provided with all the necessary supplies and with a proper tool equipment, and in a word, capable, through the means aboard, of supplying its exigencies for days and days of travel. Now, a war service can but still further amplify such a situation, and what is required for a simple trip beyond the Alps must be required still more of a car which is going to travel for some weeks over bad roads with no other resources than its own.

There is talk of mobilizing in time of war certain automobile carriages that are designated at this moment. There is considerable delusion in regard to this matter, for certainly no one would call an automobile into requisition as he would a cart. We can, even, assert as a fact that a carriage not having its own driver, and not even a driver who has had it under his control for some months, would be non-utilizable in a few hours. The same would be the case with a new carriage that had not been put in perfect trim, and in which the damages due to the first break-downs inevitable to every carriage on leaving the factory, had not been repaired.

In order to obtain an apparatus really mobilizable and capable of rendering useful service, a carriage must be found that is in a good condition, one that has been put to the test on the road, and one that has been put in perfect trim by its owner, it being understood that the latter steers his carriage himself without the aid of any machinist, knows it perfectly in every detail, and possesses all the spare pieces that he deems necessary for it. It is of prime importance, too, that such carriage shall be abundantly provided with spare pneumatic tires to meet the exigencies of a long campaign undertaken without the possibility of restocking. It seems necessary, finally, that the driving of a carriage shall be completed by the employment of a mechanic, since, in difficult cases it seems imprudent to intrust the running of a carriage to the sole strength, often inadequate, of one man only.

Thus, then, it seems evident that in case of mobilization, we must accept, only with a certain amount of caution, second-hand carriages refurbished at the last moment for the exigencies of the cause, and driven by haphazard mechanics not owners of the vehicle, or by men who know nothing at all about it. In a word, a true inquiry must first be set afoot to establish the proper operation of the automobile group that each carriage represents.

As for the ultimate destination of the carriages employed, it is evident that that may remain secret up to the last moment and depend upon the plan of mobilization. However, it would seem to be preferable to organize in advance groups consisting of many carriages which would be assigned to the service of such and such a strategic corps, division, army corps or army according to the exigencies of the plan of mobilization. It would be of interest, in fact, to group the carriages of the same kind as far as possible, and even to send them by preference in the direction of the works where they were constructed, or, more simply still, to make known their grouping in advance so that there might be a perfect understanding between the drivers of the same group in regard to the measures to be taken as to restocking the vehicles. Such an organization is now perfectly complete in Italy and Germany. France alone remains in the rear in this regard, while she should more than many others stand at the head.

As for the utilization, properly so called, of each group, it is better not to endeavor uselessly to decide upon that in advance. When once an automobile group has been placed at the disposal of a corps commander, when once this train without rails is ready to start at the first signal that is given it, we may be assured that its service will stand still neither day nor night, and that it will not cease to operate during the entire campaign. The corps commanders will thus have at their disposal a marvelous instrument of infinite flexibility which can instantaneously form itself into a true freight or passenger train, or into a train of scouts, exceedingly rapid and permitting of carrying an order more quickly than would be done by mail or even the telegraph in time of peace. The utilization of the automobile group would be different every day. One day it would effect in a few minutes the supply of ammunition to a distant line of battle; the next day a quick carriage of the wounded to the rear; and on the third it would assure the rapid carriage of the commander-in-chief from one end to the other of the line of battle. Its utilization would, I repeat, change every day and it would be useless to try to fix it in advance.

We can be sure of one thing only, and that is that by putting force and very high speed at the disposal of men to whom victory is a question of force and speed we may be certain of not deceiving ourselves. It is evident that at the last moment, in time of war, we

shall be led to utilize, cost what it may, the first carriages that are offered. Perhaps it would be better to occupy ourselves with this matter in advance. In order to obtain a serious result, we must, I repeat, make application to real owners of carriages, who possess automobiles put in perfect trim and arranged with a view to campaign purposes.

Now, upon examining things closely we shall perceive that owners who are still of the age to do military duty are not as numerous as might be thought; so, the best thing to do would be to make sure of their aid at once.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the French of G. de Pawlowski in La France Automobile.

[Continued from SUPPLEMENT No. 1580, page 25314.]

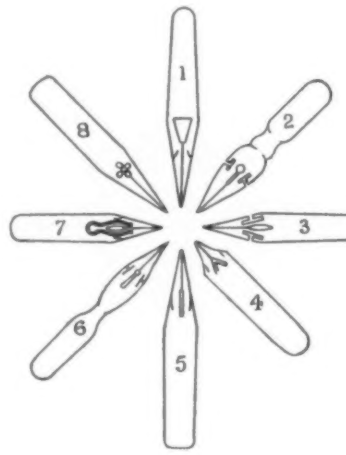
RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—II.*

By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

RESERVOIR PENS.

MANY attempts have been made to increase the ink-holding capacity of the ordinary writing pen, or nib. As already mentioned, one method of attaining this end, was the provision of an orifice or "pierce" as it is technically called, some examples of which are shown in Fig. 12.

FIG. 12.



Some nibs were provided with deep recesses or pockets as shown in Fig. 13 (*A*); Fig. 14 (*B*); Fig. 15 (429, 1883). Another favorite method was that of folding over the sides of the nibs. The nib was stamped out provided with wings, which could be folded, so as to form an ink reservoir under the nib, as in Fig. 16 (*C*); Fig. 17 (1616, 1890), and Fig. 18 (10984, 1884).

Sometimes a portion of the nib was so punched out

FIG. 13.

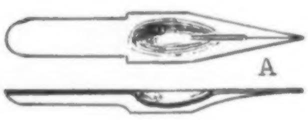


FIG. 14.

FIG. 15.

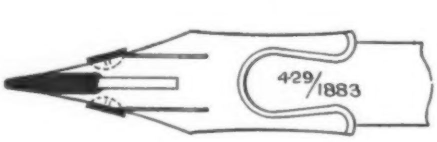


FIG. 16.

FIG. 17.

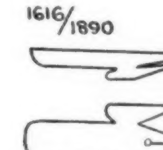


FIG. 18.

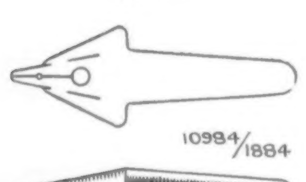


FIG. 19.

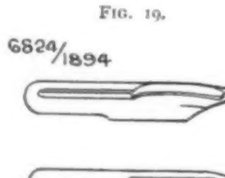


FIG. 20.

FIG. 21.

FIG. 22.

FIG. 23.

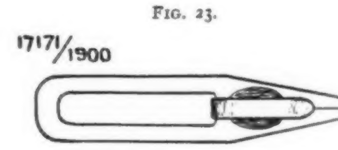


FIG. 24.

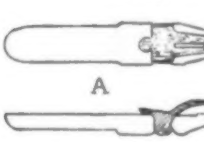


FIG. 25.

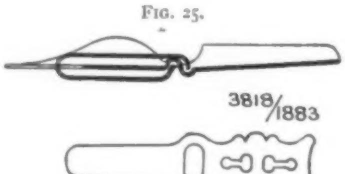


FIG. 26.

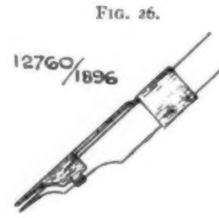


FIG. 27.

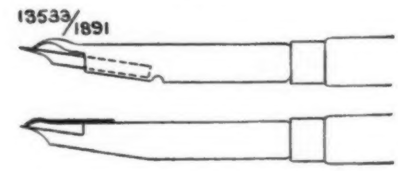


FIG. 28.

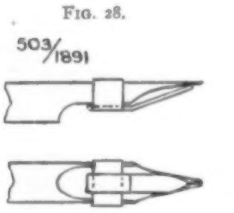


FIG. 29.

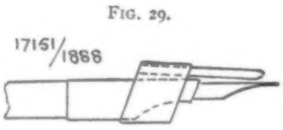


FIG. 30.

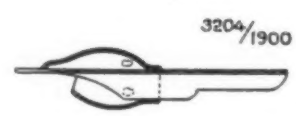


FIG. 31.

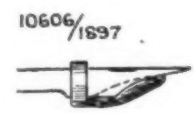
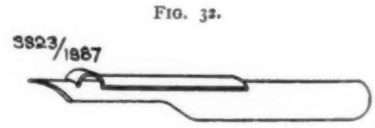


FIG. 32.



that it could be folded over on the back of the nib, as in Fig. 19 (6824, 1894), and Fig. 20 (7484, 1897). Or underneath the nib, as in illustrations Fig. 21 (*A*), and Fig. 22 (*B*), the space thus formed providing accommodation for a considerable quantity of ink. In some instances the folded part was used as a clip as in Fig. 23, to hold a pellet of aniline matter, so that on dipping the nib in water, a writing fluid resulted. Messrs. Perry & Co., some fifty years ago, introduced a similar nib, having an aniline pellet cemented underneath, and these nibs were sold at what now appear to be very extravagant prices.

Not uncommonly nibs were provided with additional parts, which were either fixed by clips or other means, as shown by Fig. 24 (*A*), Fig. 25 (3818, 1883), Fig. 26 (12760, 1896), and Fig. 27 (13533, 1891), and also in Fig. 28 (503, 1891), Fig. 29 (17151, 1888), Fig. 30 (3204, 1900), Fig. 31 (10606, 1897), and Fig. 32 (3823, 1887), or were slipped into the penholder together with the nib, as shown in Fig. 33 (16516, 1888), Fig. 34 (12999, 1896), Fig. 35 (20862, 1895), Fig. 36 (21138, 1891), Fig. 37 (*A*), and Fig. 38 (15309, 1886), or were part of the penholder, as in Fig. 39 (*B*). Another form was that in which the sides of the nib were bent into trough form, and a wire having a coiled loop was attached to the nib, lying along the bottom of the trough as in Fig. 40 (16235, 1891), or a fine wire was wound around the point of the nib, as shown in Fig. 41 (2328, 1889).

In the illustration Fig. 42 (155, 1883) we have a kind of barrel pen having a reservoir formed underneath the writing point, while the "barrel" may be inserted in a tubular holder containing a supply of ink which would gravitate to the point.

Illustration Fig. 43 (8748, 1892) shows a barrel pen formed from a flat piece of steel, bent into a tube, tapering toward the point. And the adjoining illustrations Fig. 44 (13665, 1888), show a somewhat similar pen, having four points meeting to form the writing point. The illustration, Fig. 45 (18020, 1899), shows a trough formed underneath the nib.

Several inventors have used India rubber in combination with nibs as a means of holding ink. In the first example, Fig. 46 (3808, 1893), a tiny piece of thin sheet rubber is punched out, as shown at *A*, and this is fitted to the nib by inserting the point into the openings provided. The next example, Fig. 47, is very similar (18482, 1895). In the next illustration, Fig. 48 (3788, 1894), a short piece of India rubber tubing is used; and in the fourth example, Fig. 49 (12963, 1895), a nib, of barrel form, is almost entirely inclosed in a flexible rubber tube, the point of the nib being visible.

The remaining example, Fig. 50 (7241, 1897) shows a piece of flat rubber, the ends of which are held taut by a metal ring clasping them to the penholder, while the point of the nib is just visible through a minute hole in the rubber.

In drawing Fig. 51 (12618, 1895) is shown a nib with an exaggerated "pierce" extending in tapering form about one-half the length of the nib. Into this perforation is sprung a piece of flat metal, bent like a pair of forceps. It is possible that a considerable quantity of ink might be held here, but the pen is too clumsy to meet with universal approval.

The illustration, Fig. 52 (2561, 1870), shows an addition to a nib, having a kind of counterpart pivoted underneath, and held in position against the nib by a tail spring. Although patented in 1870, this has recently been offered as a novelty.

A more recent patent, Fig. 53 (10583, 1891), is also illustrated here, in which two nibs are held together in a holder, face to face, the cavity forming an ink reservoir; and another drawing shows the lower nib pivoted into the upper one, suggestive of a bird's beak.

In Fig. 54 (3211, 1872) we have a nib which it is convenient to refer to here, although it was not primarily intended for a reservoir nib. The nib proper has no slit, but the combination of its point with the point of the overhanging plate (which, it will be observed, projects slightly beyond the nib point) forms an elastic writing point, the ink being delivered from between the two points, the object being to produce a pen having the sensation of a quill in writing.

The foregoing examples are merely typical and do not by any means exhaust the number of attempts to produce a reservoir nib. Some of them are very well in their way, and some are ingenious. They obviate the necessity of frequent dippings in the inkpot, for with some of them it is claimed that a letter may be written with one dip of ink.

So far so good, but something more is demanded. A lead pencil may be carried in the pocket, ready for use at any moment, where such an instrument is permissible. The aniline pencil came to meet a want, by supplying a more or less indelible marking agent. Ink, however, was not to be ousted, as, with its drawbacks, it is to-day the most suitable article for writing, a good ink being as permanent (and often more so) as the material upon which it is used. There was room, therefore, for some kind of pen which would carry a supply of ink sufficient to last a considerable time, and yet such a pen as could be carried in the pocket without risk of its being emptied where least wanted.

(To be continued.)

* Journal of the Society of Arts.

BENARES.

HINDUISM reveals at Benares perhaps more clearly than anywhere else one of the secrets of its hold over so many millions of people. It is both eclectic and popular. For the Hindu pilgrim not only finds here such a pantheon of the innumerable deities which are, according to the higher Brahminical teaching, merely the symbolical manifestations of the one Supreme Being, that, whatever part of India he comes from, he will discover some shrine sacred to his own favorite cult, but he can also within this small area visit sacred spots assimilated in point of sanctity to different holy places in remote parts of India and acquire the spiritual benefits of other famous pilgrimages without the toil and expense of further journeyings. Thus the Hindu from the northern plains of India can obtain at a given shrine in Benares, all the merit of a pilgrimage to Ramosvaram without traveling to Cape Comorin; and the dweller in the south, who has found his way to Benares, need not toil up into the Himalayas to earn the reward of a pilgrimage to Kedarnath. But comprehensive as is the hospitality of Benares to the vast company of gods and goddesses, it does honor, above all, to Shiva Mahadeva, or the great god whose cult is certainly the most popular and widespread at the present day—Shiva, the Lord of Life and Death, the Destroyer and the Creator, whose *sakti* is the terrible goddess, Durga, or Kali, whom blood alone can propitiate. Vishnu has left his footprints at Benares, and there are temples to Ganesha, the elephant-headed, and Hanuman, the monkey-faced, and to scores of other major and minor deities, but it is to Shiva in one or other of his manifestations that not only the great Golden Temple, but by far the largest number out of the 1,400 temples and innumerable lesser shrines of Benares are dedicated, and it is to obtain from him as Lord of Bliss, immediate admission into his reposeful realm, that the funeral pyre is kindled on the "burning *ghat*" and the ashes of the dead committed to the waters of the Sacred River.

The whole life of Benares revolves on the axis of sacrificial virtue. At the first break of dawn the daily host of pilgrims descend to the river's edge, and in sight of the rising sun perform their ablutions with an elaborateness of ritual which reaches its utmost development in the case of the twice-born Brahmin. So great is the spiritual potency of Ganges water that for the moment even caste is obliterated and the low-caste Sudra can bathe alongside the high-caste Brahmin without polluting him. Then during the forenoon a stage has to be done of the long pilgrimage through the narrow streets of the crowded city to the sacred wells and to the temples and shrines which crowd upon each other in its labyrinthine alleys like the growth of a tropical forest; and when this "perambulation" of the Holy City has at last been completed with endless offerings of flowers and rice to the gods, and libations of sacred water on the divine emblem of Shiva, and sacrifices of goat's blood to the "terrible goddess," and now and again a passing tribute of sugar-cane or green fodder to the sacred cows, no less insistent than the army of human mendicants, the indefatigable pilgrim proceeds to the great "circumambulation" of the outer limits of the Holy City, which occupies six more days. From year's end to year's end the tide of pilgrims flows perpetually, reaching the flood at certain festival seasons, but never altogether failing. And in return the whole life of Benares is dedicated to the pilgrims' service—for value received. To provide for his spiritual needs there are Brahmins to guide him on his pious errands and to recite on his behalf the most potent *mantras*, there are Sanyiasis and Saddhus to display for his benefit the most approved methods of penitential asceticism, there are qualified priests to certify that he has duly observed every iota of the pilgrim's ritual. For his material wants there are numberless hostelries and eating houses, where he can obtain food and shelter in accordance with the rigid requirements of his particular caste, there are whole streets where nothing is sold but the brass pots for ablutions, and the flowers and rice for sacrificial offerings, or the small idols and images in brass which he carries home with him as the mementoes of his pilgrimage. Even the palaces of massive stone and marble which rise in almost unbroken array along the great river *ghats* are little else than royal hostelries for pilgrims, erected by the splendid piety of Hindu princes from all parts of India for the use of their families and retainers.

Many have been the pictures painted with pen and brush of the wondrous life of Benares, so full of color and sunshine, so fascinating in its splendor, so repellent in its squalor, so mysterious in its remoteness from every western conception, and, above all, so ancient and unchanging. At Benares, perhaps as nowhere else, one realizes the meaning of the immutable East. Some four thousand years have passed since the great Aryan migration from northern climes into the plains of India which brought forth in due time by unknown processes of evolution the social and religious system which we call Hinduism. Traditions of peculiar sanctity may have attached to the country about Benares even before the advent of the northern Aryans. That it was singled out by them at a very early date as a holy place there can be no manner of doubt, for, thanks to a sudden northerly sweep of the Ganges, the bend of the Sacred River on which Benares has been built faces auspiciously toward the rising sun and Shiva's Abode of Bliss. Since then throughout the procession of the ages kingdoms have risen and fallen, conquerors have come and gone, great religious teachers have appeared and disappeared, but the ancient cult of which Benares is the supreme sanctuary has survived them all, unchanged and unchanging. More than 24 centuries ago Buddha preached hard by Benares, and the ruins of Sarnath still bear witness to the shortlived glory of Indian Buddhism. Less than three centuries ago Aurangzeb tore down a temple of Shiva in the heart of Benares and built a mosque on its site with four lofty minarets as a standing testimony to the supremacy of Islam. To-day the Dufferin railway bridge which spans the Ganges just below Benares city is an eloquent monument to the material triumphs of another alien race and another alien civilization on the ancient soil of India. Will the influences for which that great bridge stands affect any more permanently or deeply the unchanging course of Hindu life?

Perhaps the most pertinent answer to that question might be found in the records of the Indian National Congress, which, with that strange absence of humor characteristic of the Bengali mind, has chosen Benares of all Indian cities as the meeting place of a mimic western parliament. Political rights and political liberties, which have grown up in western countries as the matured fruit of a laborious social evolution, form the burden of their discussions, but seldom the duties correlated to those rights and liberties, and still more rarely the social conditions, as far as the poles asunder, which underlie them. The keynote of western society is individualism—the freedom of the individual to develop according to his natural capacities and the opportunities afforded by an elastic social framework. The keystone of the Hindu social structure is caste, which is the absolute negation of individualism—iron bound, pitiless caste, which immures the individual from his cradle to his grave within the prison house of immutable laws, customs, and traditions. What impression has contact with the West produced upon caste? One often hears it stated that the appliances of western civilization, railways, street cars, factories, etc., with the facilities and even the necessity of contact between different classes of the community, are gradually breaking down caste, and no doubt some of the superficial observances of caste have been relaxed in practice, though not in principle. But the touchstone of caste is the right of intermarriage—the old *jus connubii*—and the rigidity of the caste-laws which govern that vital point remains absolutely unshaken and untouched. That is the rock upon which the more earnest reform movement, such as the Brahmo Somaj and the Aryo Somaj, have come to grief, and which the glib talkers of the national congress seek to avoid by ignoring its existence. But so long as Hinduism rests upon that rock, Benares will remain what it has been for thousands of years and what it still is to-day—the center of a great immovable world of spiritual conceptions and emotions which defies the Western understanding as completely as the Western world of action and material energy passes the Hindu comprehension.—London Times.

Ferro-Manganese.—Ferro-manganese is attacked by water; the higher the percentage of manganese the greater is the energy of the reaction. This fact, say Herren Naske and Westermann, in Stahl u. Eisen, is due to the presence of manganese carbide, which is decomposable by water, while ferric carbide is not. In any case, the sulphur and phosphorus contained in the alloy do not cause the attack of water, which is demonstrated by the absence in the gases collected of hydrogen phosphide or sulphide. The attack of the ferromanganese by water is slow when cold, more energetic when hot, and the gases are especially composed of hydrogen and carbonic acid. Their quantity is a function of the percentage of manganese, and not of that of carbon.

PRACTICAL METHODS OF WATERPROOFING AND FIREPROOFING.

By Dr. Koller.

For making textile fabrics and pasteboard incombustible, the following methods have stood the test especially well:

1. For Light Woven Fabrics.—Ammonium sulphate 8 parts by weight, ammonium carbonate 2.5 parts, borax 2, boracic acid 3, starch 2, or dextrin 0.4, or gelatin 0.4, water 100. The fabric is to be saturated with the mixture, previously heated to 86 deg. F., and dried; it can then be calendered in the ordinary way. The cost is only two or three cents for sixteen yards or more of material.

2. For Wood, Rope, and Straw Matting.—Ammonium chloride (sal-ammoniac) 15 parts by weight, boracic acid 6 parts, borax 3, water 100. The articles are to be left in the solution, heated to 212 deg. F. for about three hours, then squeezed out and dried. The mixture costs about five cents a quart.

3. For Paper.—Ammonium sulphate 8 parts by weight, boracic acid 3 parts, borax 2, water 100. The temperature should be about 122 deg. F.

Uninflammable Starch.—Sodium tungstate, perfectly neutral, 30 parts, borax 20, wheat or rice starch 60. The constituents are to be finely pulverized, sharply dried, and mixed, and the starch used like any other. Articles stiffened with it, if set on fire, will not burst into flame, but only smolder.

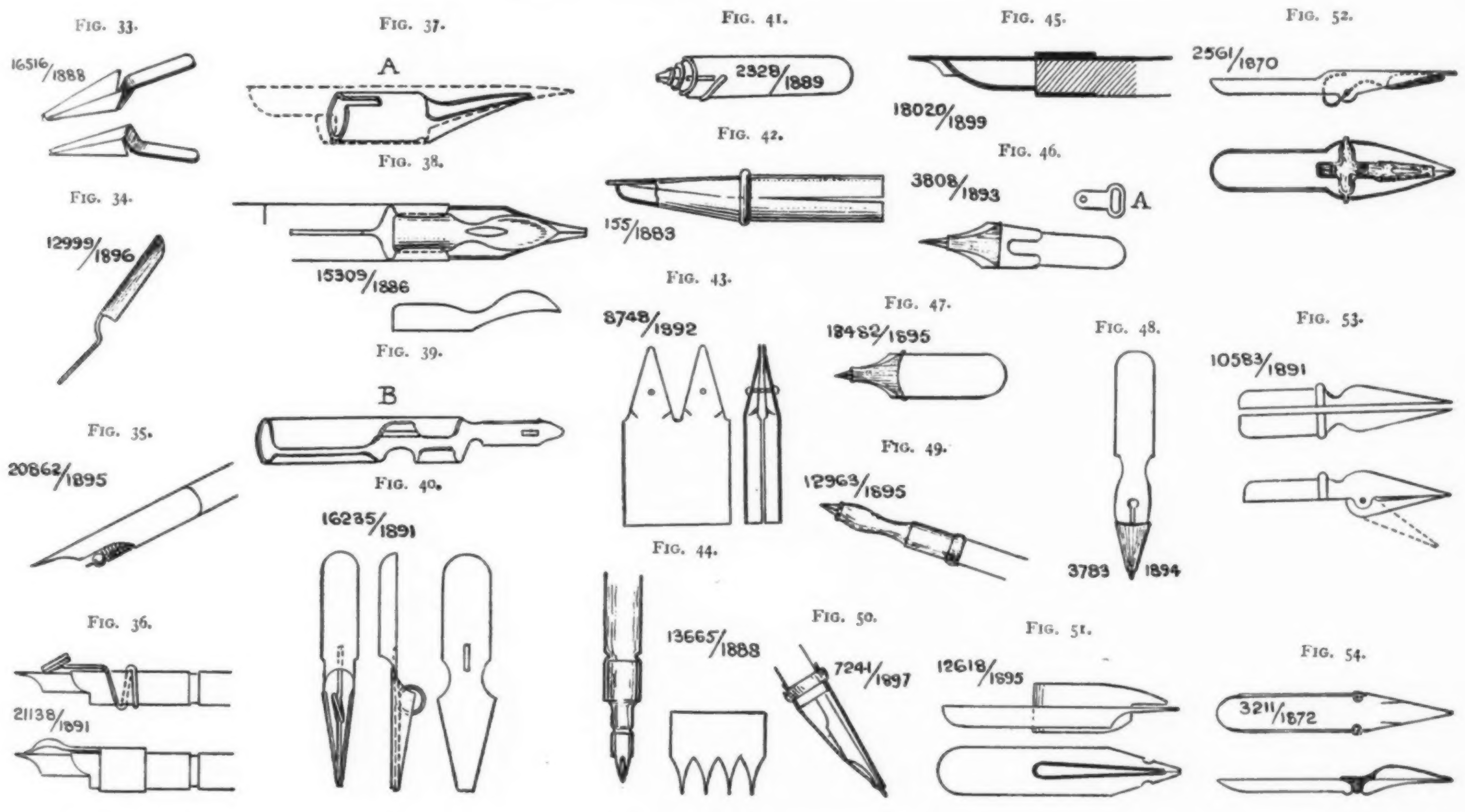
For waterproofing sacking, the two methods given below may be used with advantage:

1. Dissolve separately equal weights of alum and sugar of lead—lead acetate—in hot water, with stirring; put the solutions together and add warm water; let the goods lie in this liquid for twenty-four hours, then remove and dry.

2. Boil 50 parts by weight of isinglass in soft (rain) water until fully dissolved; dissolve 100 parts of alum in 3,000 parts of water, and 30 parts of white soap in 1,500 or 2,000 parts of water; mix the filtrates of these solutions and apply to the cloth, quite hot, with a brush.

To Make Tent Canvas Waterproof.—130 parts by weight of litharge, 130 of umber, and 11,000 of linseed oil. (For a tent of medium size, a sufficient quantity of the liquid will be made by using 4½ ounces of litharge, 4½ of umber, and 3 gallons of oil.) Boil the mixture for 24 hours, stirring frequently, in a vessel large enough so that the mass cannot boil over, on a stove-lid, not over an open fire. Apply while warm to the cloth, stretched on the tent poles, and let it dry in the sun. It is well to do this in the morning, so that the canvas will be fairly dry before the dew falls at night.

For waterproofing woolen or half-woolen materials, make a mixture of 100 parts of gelatin (animal glue), thoroughly dissolved, and 100 parts of potash-alum, and add water as necessary, according to the weight of the material, and the degree of hardness desired in the waterproof finish. After applying the mixture, the material is dressed a second time with a mixture of 5 parts of tannin and 2 of water-glass, and then



dried. Both liquids are to be used at a temperature of 104 deg. to 140 deg. F., according to the fastness of color of the material. Fugitive colors cannot withstand strong heat.

A preparation for ladies' waterproof garments is as follows: In 100 parts of water dissolve 10 parts of crystallized soda and 10 parts of colophony, and boil several hours. The resulting rosin soap is separated by adding common salt, 5 parts, then well mixed with 10 parts of white soap, previously dissolved in 100 parts of hot water, and applied to the cloth at a temperature of 140 deg. F. Another good method is to dissolve 5 parts by weight of alum and 5 of lead acetate in the necessary quantity of water, and, separately, 1 part of isinglass; dilute the first solution with 600 parts of water, mixing thoroughly. After the precipitate is well settled, pour off the clear liquid and mix with the isinglass.

A Good Preparation for Waterproofing Forester's Cloth.—Dissolve 2 parts, by weight, of alum, 1 part of isinglass, and ½ part of white soap, in 50 parts of water. The cloth is first thoroughly wet with this, and then put into a bath composed of 2 parts of lead acetate and 50 of water. Water will stand upon cloth treated in this way, for days, without soaking through.

For waterproofing army cloth, the stuff may be passed several times through a solution of aluminium sebate in spirits of turpentine, and dried in the air or at a temperature of 68 deg. to 86 deg. F.

To make canvas shoes waterproof the best method is paraffining, which is done by passing the articles through a bath composed of 30 parts, by weight, of soft paraffin, 1 of yellow beeswax, 1 of mineral wax, and ¼ part of poppy-seed oil, dissolved in 200 parts of petroleum benzine or coal-tar benzine. When the material itself is to be waterproofed, it is dried in the air after unrolling and firmly calendered.

Material for making bags, to hold bread, etc., is made waterproof by saturating with water-glass, then passing through a solution of alum sulphate or aluminium sulphate, or in some cases aluminium acetate, finally run gently through grain soap containing free fat, and gently calendered.

For making ropes and lines impervious to weather, the process of tarring is recommended, which can be done either in the separate strands or after the rope is twisted. An addition of tallow gives greater pliability.

For wood, saturation with zinc chloride or naphthalin is recommended.

A composition for protecting highly inflammable articles in general is as follows: Ammonium sulphate 8 parts, ammonium carbonate 2.5, boracic acid 3, sodium borate 1.7, starch 2, water 100. This mixture can be used for linen, muslin, etc. The material is to be immersed in it hot, and left until thoroughly saturated, then dried, ironed, and pressed, as in the case of any starched article.

Coarse canvas, sail cloth, rope, straw, and wood may be soaked in a mixture of boracic acid 6 parts, ammonium chloride 5 parts, sodium borate 3, and water 100.

For paper, either printed or unprinted, bills of exchange, deeds, books, etc., the following solution is recommended: Ammonium sulphate 8 parts, boracic acid 3, sodium borate 1.7, water 10,000. The solution is heated to 122 deg. F., and may be used when the paper is manufactured. As soon as the paper leaves the machine, it is passed through this solution, then rolled over a warm cylinder and dried. If printed or in sheets, it is simply immersed in the solution, at a temperature of 122 deg. F., and spread out to dry, finally pressed to restore the luster.—Neueste Erfindungen und Erfahrungen.

GAS PRODUCERS FOR POWER.*

By Julius Wile.

It is well known that steam boilers and engines, even when used with condensers, superheaters and economizers, realize only a comparatively small part of the original heat of the fuel. The highest combined thermal efficiency yet obtained in steam practice is approximately 15 per cent of the original value of the coal converted into work, while efficiencies of 3 to 6 per cent are more common, especially in units of from 50 to 250 horse-power, where non-condensing engines are usually employed. With the gas producer and producer gas engine an efficiency of over 22 per cent is now common and even in comparatively small units, while the tendency of this latest power is toward even higher efficiencies, as high as 24 per cent having already been obtained. A comparison of efficiencies of steam engines and boilers with producer gas engines and gas producers using various fuels is of interest:

EFFICIENCIES OF STEAM ENGINES AND BOILERS.

Coal taken at 13,000 B. T. U. per pound.

Type.	Pounds of coal per B. H. P.	Thermal efficiency. Per cent.
Simple non-condensing, throttling	6	3.28
Simple non-condensing, automatic	4½	4.35
Simple non-condensing, Corliss	3½	5.6
Compound non-condensing, Corliss	3	6.55
Compound condensing, Corliss	2¼	8.75
Steam turbine condensing, Corliss	1¾	11.25
Triple condensing, Corliss	1⅓	14.75

* From a paper read before the Technology Club, Syracuse, N. Y., February 13. Mr. Wile is president of the Wile Power Gas Company, Rochester, N. Y.

EFFICIENCIES OF GAS ENGINES AND PRESSURE GAS PLANTS.

Brake horse-power.	Type of producer.	Type of engine.	Fuel.	B. T. U. per pound.	Fuel consumption in pounds per B. H. P.		Thermal efficiency.	
					Producer.	Boiler.	Total per cent.	
250	Taylor	Westinghouse 3-cylinder	Colorado bitum.	9,767	1.66	0.29	1.95	[illegible]
250	Wilson	Stockport single cylinder	Bituminous	*11,000	1.26	0.14	1.4	[illegible]
280	Dowson	Campbell 4-cylinder vertical	Anthracite	*13,600	0.99	0.13	1.12	[illegible]
3,000	Dowson	Westinghouse 3-cylinder	Anthracite	*13,600	1.07	0.13	1.20	[illegible]

* B. T. U. of the coal is assumed.

EFFICIENCIES OF GAS ENGINES AND SUCTION GAS PLANTS.

Brake horse-power.	Type of engine.	Fuel.	B. T. U. per pound.	Fuel in pounds per B. H. P.	Thermal efficiency, per ct.
20	National, single cyl.	Anthracite.	15,138	0.797	21¼
90	Crossley, single cyl.	Coke.	12,411	0.91	22⅔
250	Deutz, double acting	Anthracite.	14,600	0.744	23⅓
300	Crossley, 2-cylinder.	Anthracite.	11,370	0.978	24

The above results are from actual tests, and where the heat units in a pound have not been given in the reports they have been assumed. It will be noticed that suction gas producers are more efficient than the pressure types, while anthracite coal pressure producers are more efficient than bituminous pressure gas producers.

THE BLAST FURNACE AN IDEAL GAS PRODUCER.

Producer gas is the result of incomplete combustion of fuel due to the absence of sufficient oxygen to support combustion, and for its formation a deep fuel bed is essential. An ordinary blast furnace is an ideal gas producer, as the body of coal or coke is subject to a blast of air beneath the fuel bed, but there is no provision above for burning the carbon monoxide (CO) formed by partial combustion to carbonic acid gas (CO_2). The gas from a blast furnace has the lowest heat value per cubic foot of any producer gas, being only approximately 90 British thermal units per cubic foot. A notable plant where blast furnace gas is used is that of the Lackawanna Steel Company at Buffalo. In this plant there are 16 2,000 horse-power gas driven blowing engines as well as eight 1,000 horse-power gas engines driving alternating current and direct current generators, making a total of 40,000 horse-power. For every ton of pig iron produced after the waste gases have been used to heat the air blast there is still in them an amount of power equivalent to 600 horse-power hours. For doing the work of the blast furnace about 240 horse-power hours are necessary, which leaves 360 horse-power hours available for other purposes. To make this gas suitable for use in a gas engine it is necessary that it be thoroughly cleaned of all impurities, and a cleaning apparatus is common to all forms of gas producers used for power purposes. It has been found that on account of the minute particles of dust and the different classes of iron as well as coke or coal which are used in the blast furnace a cleaning apparatus suitable for one class of gas is not always suitable for another.

The following table gives the heat value and chemical composition of various gases used in gas engines:

HEAT VALUE AND CHEMICAL COMPOSITION OF VARIOUS GASES.

	H	CH_4	C_2H_4	CO	CO_2	N.B.	T.U.
Blast furnace gas	1	..	..	25	12	62	90
Producer gas from anthracite	12	1.5		27	3.5	57	140
Producer gas from bituminous coal	10	6.5	..	15	10	58	150
Blue water gas	44.5	..	..	42	3.5	10	295
Coke oven gas	39	40	5	5	3	8	600
Coal gas	45	38	6	6	1	4	720
Natural gas	2	95	..	..		3	1,020

Another form of gas producer is the by-product coke oven. In coking 1 long ton of coking coal in a retort 8,000 to 10,000 cubic feet of gas is generated, carrying from 60 to 100 pounds of tar and 10 to 20 pounds of ammonia sulphate. The sale of these products usually covers the cost of their extraction. About one-half of the total value of the gas, which is approximately 600 British thermal units, is required for carrying on the coking process, so that from 1 ton of coal there is available about 200 effective horse-power hours.

GAS PRODUCERS.

Blast furnaces and coke oven furnaces are only local, and natural gas is also confined to certain districts, so that there is a large field for gas production by gas producers. The gas made in gas producers has a higher value than blast furnace gas, due to the introduction of steam, which is decomposed into hydrogen and oxygen, with the twofold advantage of adding hydrogen to the gas and oxygen to support combustion, without introducing large quantities of inert nitrogen, as when air is admitted. Producer gas has a calorific value of approximately 140 British thermal units per cubic foot, depending upon the type of producer. With different types the proportions of CO_2, CO, and H vary, but the general average is approximately as given in the table.

The two general types of gas producers, pressure and suction, make comparatively the same quality of gas. The characteristic of the pressure type is that the complete system is under pressure, supplied either by a steam jet blower or a power driven fan. A gas holder is necessary for storing the gas, and also an independent steam boiler. In the suction type the complete system is under suction from the engine, which causes the draft. Both the holder and independent steam boiler are done away with, and steam at atmospheric pressure is raised by the hot gases from the generator passing to the cleaning apparatus. The space occupied by the suction type is less than that of the pressure, and is less than the space taken by a return tubular boiler of the same power. The attention is also considerably less than that required by the pressure type. In the pressure type unless automatic feeders are installed it is necessary to feed once every half hour. Suction producers are fitted with large reservoirs, so that feeding is only necessary once in three hours at full load and once in five hours at half load. The total attention otherwise required is 15 minutes starting up in the morning and 20 minutes cleaning at night.

The first pressure gas producer was brought out by Dowson in England. The best known Dowson plant is that at Walthamstow, London, England, where there is a 3,000 horse-power (2,000 kilowatt) plant, comprising eight Dowson gas generators and 13 direct coupled vertical engines. The generating cost per kilowatt hour of this plant complete, including fuel, supplies, labor, and repairs, will be of interest especially when compared to the average of eleven steam plants in London, which have about three times the output.

The saving in cost per kilowatt is almost one-half cent. These costs are high, for both coal and water are high in the London district, as the cost of anthracite coal used was \$6.75, while the steam coal costs about \$5 per ton. Even under these disadvantages it is seen that the Walthamstow plant shows a saving of 38 per cent in fuel and 21 per cent in operating cost. If the cost of fuel were the same the saving in fuel would be 51 per cent, and in operating cost 29 per cent. The test of another gas producer pressure plant and steam plant at Guernsey, England, gives even better results:

COMPARATIVE TESTS OF STEAM AND PRESSURE GAS POWER PLANTS, LONDON DISTRICT.

	Kilowatt capacity.	Output units.	Load factor.	Cost of fuel per ton.	Cost per unit. Fuel.	Supplies.	Labor.	Repairs.	Total.
			Per cent.	\$	C.	C.	C.	C.	C.
Average 11 steam plants	2,799	2,997,500	17.25	5.00	1.194	0.118	0.418	0.436	2.176
Pressure producer gas	810	1,019,326	15.45	6.75	0.736	0.304	0.576	0.096	1.712
Difference	−1,989	−1,978,174	−1.80	+1.75	−0.458	+0.186	+0.158	−0.340	−0.464

RESULT AT PLANT AT GUERNSEY, ENGLAND.

	Kilowatt capacity.	Output units.	Load factor.	Cost of fuel per ton.	Cost per unit. Fuel.	Supplies.	Labor.	Repairs.	Total.
			Per cent.	\$	C.	C.	C.	C.	C.
Steam plant	180	55,108	45.6	4.20	1.178	0.156	0.284	0.512	2.130
Gas plant	180	50,361	65.8	4.43	0.496	0.096	0.304	0.208	1.104
Difference	....	−4,847	+20.2	+0.23	−0.682	−0.060	+0.020	−0.304	−1.026

At above loads, coal per unit ... { Steam, 6,131 pounds. Gas..... 2.44 pounds. } Above test covers a period of one month.

It will be noted in this plant that the saving is 58 per cent in fuel and 48 per cent in operating cost.

The first pressure plants were originally designed to use anthracite coal, as bituminous coal involves considerable waste of water and power on account of the nuisance in getting rid of the volatile matter containing tar. Bituminous coal is not suitable for small gas producers, on account of the tendency of the fuel to clinker, thus preventing the air and steam passing through the fuel bed, and also due to the tendency for hollow spaces to be formed in the bed, so that air passes through and a poor and non-uniform quality of gas is made. A fairly good size bed of fuel is necessary, and for this reason bituminous coal producers are seldom used below units of 200 horse-power. Pressure producers with tar extracting devices are also used for burning wood and lignite.

In England the best known soft coal producer for power plants is the Wilson, which is a Dowson pressure type of plant with modifications adopted toward depositing a large amount of the tar in a dust catcher and cooling towers before going to the coke scrubber. The plant is also fitted with a hydraulic washer and sawdust purifier for taking out the remaining traces of tar. In this type of plant there is no attempt made to recover the tar and utilize it to enrich the gas, all efforts being toward washing it out. Still the results of this type of plant are good, as the following table of four independent tests of a 250-horse-power Wilson plant, conducted in Liverpool with variable loads, will show:

TESTS OF A WILSON PRODUCER.

Date, 1904	Feb. 27	Mar. 3	Mar. 4	Feb. 26
Amount of load	¼ load	½ load	¾ load	full load
Duration of tests	5 hours	10 hours	10 hours	10 hours
Fuel used in producer, lbs.	560	1,568	2,296	2,744
Fuel used in boiler, lbs.	56	224	280	306
Totals	616	1,792	2,576	3,050
Kilowatt hours per watt-meter	187	717	1,060	1,369
Dynamo efficiency, p. c.	79	87	89	90
B. H. P. hours	317	1,104	1,596	2,039
Pounds of coal per B. H. P. hour	1.9	1.6	1.6	1.4
Engine efficiency, p. c.	63	77	83	86
I. H. P. hours	503	1,433	1,922	2,370
Pounds coal per I. H. P. hour	1.2	1.2	1.3	1.2

12½ per cent of the weight of fuel charged into producer was withdrawn as ash during each test period.

Level of fuel in producer kept up to given point.

Fuel used, Nottingham fine bituminous slack, at $1.40 per ton at pit mouth.

Cost of fuel per I. H. P. = 75 cents.

One and four-tenths pounds of coal per brake-horse-power-hour is the result of using bituminous slack coal with 12½ per cent ash. It will be noticed that about 10 per cent of the fuel is used to raise steam in the boiler. The above table will also give a very good idea of the consumption of fuel of a gas engine at variable loads.

The generator used is the ordinary water bottom generator, which is in general use in connection with steel and glass works for making producer gas for fuel purposes. These producers are designed so that they can be cleaned of ash while they are in operation, and with ample facilities for poking.

The nearest approach to this type of producer in this country is the Taylor producer, upon which tests were made at St. Louis within the past year by the United States Geological Survey. These tests were valuable as far as showing the efficiencies of different coals throughout the country for use in gas producers, but as to the best results to be obtained for production of power, due to the more recent types, this type of plant is open to the following criticisms: No attempt was made to utilize the value of the heat in the tar; the steam necessary for the plant was raised in an independent boiler, which requires excess fuel; further, extra power and consequently fuel, and also large quantities of water were required to wash out the tar. The main reason why this plant is not as efficient as the Wilson is because the scrubbing device is of the rotary type and requires power, while the Wilson uses the static type of scrubber. The efficiency of these producers is from 60 to 65 per cent.

The present tendency of American practice is to depart from the former method of washing the volatile matter containing the tar out of the gas, and to build a gas producer plant which will get rid of the tar by decomposing it in the producer by passing it through an incandescent fuel bed and fixing its components, hydrogen and carbon, which give free hydrogen or marsh gas, thereby receiving the additional advantage of the heat of the tar, and doing away with the excess power and water required to clean it. It is an open question which of the two types of producers is the better, the less efficient but more reliable continuous cleaning and less costly European producer or the more efficient but complicated and expensive American type.

THE WILE GAS PRODUCER.

An interesting departure from the current practice in pressure plants where the generator is under suction is the automatic system as manufactured by the Wile Power Gas Company, Rochester, N. Y., which substitutes a small regulating receiver for a large gas holder. The use of the automatic regulating receiver does away with the attention of the man, as it automatically makes its gas as required. This is done by the introduction of a third return pipe from the gas receiver to a hydraulic seal box, so that when the receiver rises to its top position the third return pipe and valve are opened and put in communication with the seal box, and the exhauster instead of sucking from the generator sucks from the holder. When the holder tends to go down the valve closes and the exhauster at once sucks from the generator. In actual practice the holder is always kept at the top.

From the data which have been given it will be seen that the suction gas producer is the type of gas producer which has shown the greatest development for producing power. It is now being used on both land and water. On land its greatest use is for electric lighting plants, pumping plants and for power purposes in factories where large quantities of heat are not required; on water, towing barges are now in daily use. On the River Elbe the cost of towing has been reduced from 0.4 cent per ton per mile by steamboat to 0.25 cent with gas power.

The suction gas producer to-day is limited to the use of anthracite pea coal, charcoal and coke, while in large sizes anthracite buckwheat coal can be used. Soft coal has not yet been successfully used in suction gas producers, but experiments are now being made which will probably lead to a successful bituminous coal suction gas producer. The success of the suction gas producer is not entirely due to the remarkable fuel economy over steam plants, but is also due to the small amount of attention required, from one to two hours a day, depending upon the size of the plant. There are suction producers in operation which run 144 hours a week without shut-down.

The weakness of suction gas producers heretofore has been their inability to make a uniform quality of gas with variable load. This has now been overcome by introducing a secondary air supply, by which the ratio of air to steam, and consequently the temperature of the fire, can be controlled. The tendency in the ordinary suction producer is for all the steam which is made to be drawn into the fire. This has resulted in trouble, due to the fact that in some cases at light loads too much steam has been taken into the fire, which is consequently in poor condition to respond to an increase of load. The addition of the secondary air supply enables an extra amount of air to be taken into the fire and at the same time offsets the tendency of excess steam, which escapes through the primary air cocks. Another great assistance in maintaining a fuel bed which will respond quickly to changes in load is the advantage of preheating all the air and steam which enter the fire.

When installing suction producers care should be taken that sufficient purifying plant is supplied, otherwise the pipes are in time liable to clog with the accumulated dirt.

THE AUTOMATIC TELEPHONE: ITS MERITS AND ITS FAULTS.*

By J. J. CARTY.

WITH reference to automatic telephone switchboards I may say that such types of apparatus have, during the past few years, become a matter of great interest and the subject of much discussion among telephone engineers, and as I have made a number of special investigations into this subject I think it would be of interest if I here briefly state some of the results which I have obtained.

Upon a first view of the case the idea of using automatic machines and thus doing away with the labor of telephone operators appeals with much force, and the wonderful things which have been accomplished by American labor-saving inventions naturally come to mind. Among all of these projects for saving labor by automatic machines none seems more wonderful than the little machine which, when manipulated by the subscriber, will put him into communication with any one out of thousands or tens of thousands of people scattered over a wide area. But in order that an automatic telephone switchboard should be properly called a labor-saving machine it must accomplish its work at an expense entailing less annual charges than would be required by the system which it attempts to displace. If it should be found that the annual charges of operating the automatic system were equal to or greater than the annual charges of operating the manual system, then the automatic system would not be a labor-saving one, and, considered from the standpoint of costs, would be a failure. Whatever merit it would have, in that event, must be looked for in some very superior results in the way of service. From this point of view I have considered the merits of the various automatic switchboard systems which have thus far been installed.

I find that, taking into account all of the factors involved, and which go to make up the total annual charges which could properly be placed against the automatic switchboard system, on the one hand, and the manual system on the other hand, leaving out of account switchboards suitable for use only in small villages, and making comparison up to switchboards of 10,000 lines capacity, the annual charges upon the automatic system are substantially greater than the annual charges upon a manual system operated on the common battery multiple plan. From the standpoint of costs, therefore, the automatic system fails when placed in competition with the common battery multiple-board operated manually.

Having found that the automatic system could not successfully compete with the manual system in point of costs and annual charges, I made a careful investigation to determine whether the automatic system possessed any advantage of working over the manual system which might compensate for the extra annual charges which its use necessitates. For this purpose there were made about 7,500 service tests on manual switchboards operating under practical conditions in different parts of the country. The results of these tests showed that the manual system possessed a most substantial greater degree of reliability than the automatic system. The difference in speed of connection between the two systems was so small as not to constitute a practical factor, the time elapsing between the start of the call and the answer of the called subscriber being in the case of the automatic system 19.9 seconds, and in the case of the manual system 21.7 seconds. These figures include the time taken by the subscriber to answer, and even this small difference of time was found to be due to the fact that the subscribers whose lines were tested answered somewhat quicker in the automatic system than in the manual system. It will be seen, therefore, from these tests that the automatic system possesses no practical service advantages over the manual system, and that it contains no elements sufficient to warrant any part of the extra cost which its use involves. A full consideration of the details of the comparison of these types of switchboards would lead me far beyond the limits assigned to this paper, and would only result in showing that the alleged advantage of doing away with the operators at the central office is imaginary and not real.

All of the foregoing relates to switchboard systems smaller than 10,000 lines, no automatic switchboard of larger size having been installed.

In order to determine whether for systems larger than 10,000 lines the automatic principle might be made applicable, I made a study, assuming a system of 100,000 lines to be equipped with automatic switchboards, and compared this with a similar system equipped with common battery multiple switchboards operated on the manual basis. Here again the comparison is in favor of the manual board, both in point of annual charges and in respect to the service.

In applying the automatic switchboard to this 100,000-line study, it was necessary to leave out of consideration a very large class of difficulties which crop out at every turn when the attempt is made to apply the automatic principle to the complex conditions which obtain in and around all large cities. Inasmuch, however, as the study showed that the automatic system is inferior to the manual system for a 100,000-line plant, it became unnecessary to take into account the large number of adverse factors which must be charged against the automatic plan of working. So important are these factors that it is safe to say that even if the annual charges on the automatic system were substantially less than those on the manual system, they would constitute such a serious objection to the automatic system as to bar its use.

Throughout these investigations the importance of retaining at the central office operators to receive and attend to the subscribers' calls has been emphasized in so many important and unexpected ways that I have no hesitation in saying that no plan thus far employed, which requires that the subscriber should operate a machine and send his call automatically to the central office, can successfully compete with the plan which requires that the subscriber should remove the telephone from the hook and send the call orally to an operator at the central office.

* Abstract of a paper read before the American Institute of Electrical Engineers.

CONTEMPORARY ELECTRICAL SCIENCE.*

ELECTRO-MECHANICS.—E. Riecke summarizes the attempts hitherto made to connect the electric conduction in metals with the transportation of ions and electrons in their interior. The most fruitful of fields for such speculations lies in the comparison of thermal and electric conductivity. Three theories including these values have been formulated, one by Drude, another by Lorentz, and a third by the author. All these theories involve the same quantities. Their result for the ratio of thermal to electric conductivity only varies as regards a numerical factor, which is 3/2 in the author's theory, 4/3 in that of Drude, and 8/9 in Lorentz's more general theory. A matter in which theory is at present still somewhat at a loss concerns the four magnetic effects, but in bismuth, nickel, and cobalt the order of magnitude of the quantities is at least accounted for. Planck's law of radiation is fully explained for long waves.—E. Riecke, Physikalische Zeitschrift, November 9, 1905.

ELECTRIC PRECIPITATION OF COLLOIDS.—An essential characteristic of colloid solutions is that their particles are precipitated at one of the electrodes when a current is passed through. A. Schmauss has studied this precipitation, and found it to vary with the conductivity of the solvent. If this is less than that of pure water, three zones make their appearance, one of them being free from colloid particles, one of them containing the precipitate, and the intermediate space containing the unchanged solution. When the solvent is water, there are four zones, the additional zone being round the empty space at the cathode and containing concentrated colloid. The author used colloid solutions of gold and silver prepared by Bredig's method. He found a speed of the ions amounting to 0.00026 centimeters per second, that being of the order of the usual monovalent ions. This considerable speed means the presence of high electric forces. A study of the current strength led the author to conclude that the water is decomposed into ions whose condensing capacity accounts for the additional zone, and whose charges, added to the small charges of the colloid particles, produced the high speed. The ions are probably *H* and *OH*. The ions at the anode produce concentrations in the shape of rings round it.—A. Schmauss, Annalen der Physik, No. 13, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

LIGHTNING AND THE ELECTRICITY OF THE AIR.*

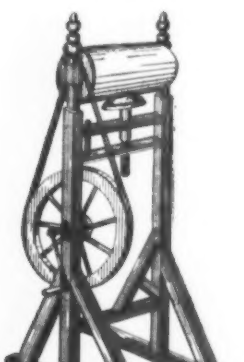
By Alexander G. McAdie.

FRANKLIN'S KITE EXPERIMENT.

One hundred and sixty years ago a ragged colonial regiment drew up before the home of its philosopher-colonel and fired an ill-timed salute in his honor. A fragile electrical instrument was shaken from a shelf and shattered. Franklin doubtless appreciated the salute and regretted the accident. In the course of his long life he received other salutes, as when the French Academy rose at his entrance, and he constructed and worked with other electrometers; but for us that first experience will always possess a peculiar interest. The kite and the electrometer betray the intention of the colonial scientist to explore the free air, and, reaching out from earth, study air electrification *in situ*. He made the beginning by identifying the lightning flash with the electricity developed by the frictional machine of that time. A hundred patient philosophers have carried on the work, improving methods and apparatus, until to-day we stand upon the threshold of a great electrical survey of the atmosphere. It is no idle prophecy to say that the twentieth century will witness wonderful achievements in measuring the potential of the lightning flash, in demonstrating the nature of the aurora, and in utilizing the electrical energy of the cloud. The improved kite and air-runner will be the agency through which these results will be accomplished.

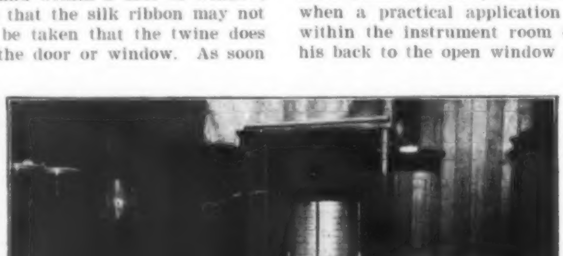
The famous kite experiment is described by Franklin in a letter dated October 19, 1752:

"Make a small cross of light sticks of cedar, the arms so long as to reach to the four corners of a large, thin silk handkerchief when extended. Tie the corners of the handkerchief to the extremities of the cross, so you have the body of a kite which, being properly accommodated with a tail, loop, and string, will rise in the air like those made of paper, but being made of silk is better fitted to bear the wet and wind of



FRANKLIN'S ELECTRICAL MACHINE.

a thunder gust without tearing. To the top of the upright stick of the cross is to be fixed a very sharp-pointed wire rising a foot or more above the wood. To the end of the twine next the hand is to be tied a silk ribbon, and where the silk and twine join a key may be fastened. This kite is to be raised when a thunder gust appears to be coming on, and the person who holds the string must stand within a door or window, or under some cover, so that the silk ribbon may not be wet; and care must be taken that the twine does not touch the frame of the door or window. As soon



MULTIPLE QUADRANT ELECTROMETER USED AT BLUE HILL OBSERVATORY.

as the thunder clouds come over the kite, the pointed wire will draw the electric fire from them, and the kite with all the twine, will be electrified, and stand out every way and be attracted by an approaching finger. And when the rain has wet the kite and twine you will find the electric fire stream out plentifully from the key on the approach of your knuckle."

Now, how would we perform this experiment to-day and with what results? Having flown big kites during thunderstorms, it may perhaps be best to describe step by step two of these experiments, and then speak of what we know can be done, but as yet has not been done.

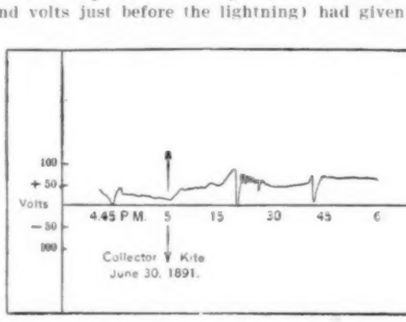
Our first repetition of Franklin's kite experiment was at Blue Hill Observatory, some ten miles south-

U. S. WEATHER BUREAU ON FARALLON ISLAND.

west of Boston, 133 years after its first trial. There were two large kites silk-covered and tin-foiled on the front face. These kites were of the ordinary hexagonal shape, for in 1885 Malay and Hargrave kites were all unknown to us. Fifteen hundred feet of strong hemp fishline was wrapped loosely with uncovered copper wire of the smallest diameter suitable, and this was brought into a window on the east side of the observatory, through rubber tubing and blocks of paraffin. Pieces of thoroughly clean plate glass were also used. Materials capable of giving high insulation were not so easily had then as now. We knew very little about mica; and quartz fibers and Mascart insulators could not be obtained in the United States. Our electrometer, however, was a great improvement upon any previous type, and far removed from the simple pith-ball device used by Franklin. Knowing that an electrified body free to move between two other electrified bodies will always move from the higher to the lower potential, Lord Kelvin devised an instrument consisting of four metallic sections, symmetrically grouped around a common center and inclosing a flat free-swinging piece of aluminium called a needle. The end of the kite wire is connected with the needle and the sections or quadrants are alternately connected and then electrified, one set with a high positive potential, say 500 volts, and the other with a corresponding negative value, say 500 volts, lower than the ground.

Perhaps the most noteworthy result of these earlier experiments was the discovery (for such we think it was) that showery or thunderstorm weather was not the only condition giving marked electrical effects. The electrometer needle would be violently deflected and large sparks obtained at other times. Day after day as we flew the kite we found this high electrification of the air, and we had no trouble in getting sparks even when the sky was cloudless. One other discovery was made, and this would have delighted Franklin more than the other, for he was always most pleased when a practical application was in sight. Seated within the instrument room of the observatory, with his back to the open window through which came the kite wire carefully insulated, and the kite high in air, the observer closely watching the index of the electrometer could tell positively, and as quickly as one outside watching the kite, whether it rose or fell. When the kite rose, up went the voltage, and *vice versa*. In other words, the electric potential of the air increased with elevation. It must be confessed that the kites made to-day would have behaved better and flown with more steadiness than the one we used. It may have been the varying wind, or more likely wrong proportions in the kite and tail; but our old hexagonal kite would dive even when high in air. Once we kept the kite aloft from the forenoon until late at night, but that was something unusual.

Passing now over six years in which we have been busy measuring the electrification of the air under all conditions, and discovering, for example, that a snowstorm was almost identical with a thunderstorm in its tremendous electrical changes, we come to the year 1891, when we again flew kites for the purpose of electrically exploring the air. Our experiments at the top of the Washington Monument in 1885 and 1886 (especially those during severe thunderstorms, when we obtained potentials as high as three and four thousand volts just before the lightning) had given us an



ELECTRICAL POTENTIAL OF THE AIR.

Small collector about 15 feet from ground. Kite about 500 feet from ground.

insight into the strains and stresses in the air, and taught us what to expect at such times. There was still little improvement in the kite, but much better electrical apparatus was at hand. It may seem ridiculous, but we hauled nearly a wagon load of electrical apparatus to the summit of the hill, and found occasion to use all of it. Our insulators were delicate glass vessels curiously shaped, containing sulphuric acid, and able to hold with little leakage the highest known potentials. Besides these fine Mascart insulators, we had hundreds of distilled-water batteries and two electrometers, one a Mascart quadrant, the other a large multiple quadrant. The chief aim that year was to secure by mechanical means (discarding the photographic and eye methods) a continuous record of the potential. When we can study the potential at any moment and still have a record of it the relation of the electricity of the air to the pressure, temperature, and moisture will be more easily investigated. Among our records that year there is one date, June 30, 1891, when a direct comparison of the electrification of the air fifteen or twenty feet from the ground and at a height of about 500 feet is shown. In one, the potential was obtained by a water-dropper collector from a second-story window in the observatory, and in the other was obtained by means of the kite. It will be seen how much higher the kite values are, although the kite was a much slower accumulator of electricity. In the next year, 1892, the kite was flown several times during thunderstorms, but generally during afternoon storms; and in the lull preceding the wind rush the kite would fall. It was not until August 9, that we succeeded in going through a storm with the kite still flying. About 11 A. M. the kite was sent aloft, and it remained aloft until after 10 P. M. From the observatory one can see to the west fifty or more miles, and a thunderstorm came into view just before sunset. The kite was flying steadily, and whenever a finger was held near the kite wire there was a perfect fusillade of sparks. As the darkness increased, the polished metallic and glass surfaces in the large electrometer reflected the sparks, now strong enough to jump across the air gaps, and the incessant sizzling threatened to burn out the instrument. The vividness of the lightning in the west also made it plain that the storm was one of great violence, and as the observatory itself would be jeopardized, one of the four men present proposed to cut the wired string and let the kite go. But even that was easier said than done, for to touch the

* Reprinted from Journal of Electricity, Power and Gas.

string was to receive a severe shock. It was necessary, however, to get out of the scrape, and one of the party took the kite string and broke the connection with the electrometer and insulators. While he was in the act of doing this, the others, who by this time were outside the building, saw a flash of lightning to the west of the hill. The observer who was undoing the kite wire did not see this flash. He saw a brilliant flare-up in the electrometer, and at the same instant felt a severe blow across both arms. Notwithstanding, he loosened the wire, and dropping an end without, it took but a few moments to make it fast on the hillside some distance away from the observatory. There it remained for the rest of the night. A 105-volt incandescent lamp was placed between the end of the kite wire and a wire running to the ground. There was some light, but no incandescence of the filament. It was more in the nature of a creeping of the charge over the outer glass surface of the lamp. Stinging sparks were felt whenever the kite wire was touched. The storm gradually passed over, the lightning being vivid and frequent in the west and north, and, as we learned next day, doing considerable damage. The nearest flash to the hill, however, as well as we could determine by the interval between thunder and flash, was 4,500 feet away, so that the discharge which the observer felt while loosening the wire must have been a sympathetic one. We obtained a photograph of the prime discharge, and very curiously this shows a remarkable change of direction.

This year, in some interesting experiments made on the roof of the Mills Building at San Francisco, it was noticed that the roof, which has a covering of bitumen, was a good insulator. Ordinarily one may touch the reel on which the kite wire is wound without being shocked, but if a wire be connected with the ventilating pipes running to the ground there are small sparks. Introducing a condenser in the circuit, the intensity of the spark is increased. It only remains to construct an appropriate coil of the kite wire and place within it an independent coil. In the outer coil a quick circuit breaker may be placed, and theoretically, at least, we shall transform down the high potential and low amperage charge of the air to a current of less potential and greater amperage. This can be put to work and the long-delayed realization of Franklin's plan of harnessing the electricity of the air will be consummated.

ELECTRIFICATION OF THE ATMOSPHERE.

Franklin, in addition to many other experiments upon the electrification of the air, erected upon his house an iron rod with two bells. When the rod was electrified the bells were run. By charging Leyden jars and testing the sign of the electrification, he came to the conclusion that "the clouds of a thunder gust are most commonly in a negative state of electricity."

A detailed history of most of Franklin's colaborers may be found in the accounts given by Exner,*, Hoppe,† Mendenhall,‡ Elster and Geitel.§ The author‖ has also given a brief summary.

The following table will give at a glance the work of the chief investigators from the time of Franklin to the end of the eighteenth century. Passing Peter Collinson, of London, who introduced to the notice of the Royal Society the experiments of Franklin and the three less known workers—J. H. Winkler, who wrote in 1746 on the electrical origin of the weather lights; Maffei, 1747; and Barabet, 1750—we have:

Date.	Name.	Experiments.	References.
1751	Franklin	Effects of lightning	Phil. Trans., xlvii., p. 289
1751	Mazeas	Kite experiments	Phil. Trans., 1751, 1753.
1752	Nollet	Theory of Electricity	Recher. sur la causes, 1749-1754
1752	Watson	Electricity of clouds	Phil. Trans., 1751, 1752
1752	De Lor de Buffon	Iron pole 99 ft. high, mounted on a cake of resin 2 ft. sq., 3 in. high, Estrapade, May 18, 1752.	Letter of Abbe Mazeas, dated St. Germain, May 20, 1752.
1752	D'Alibard	Sparks from thunder clouds, 40 ft. pole in garden at Marly, also wooden pole 30 ft. high, at Hotel de Noailles	Mem. l'Acad., r. des Sci., May, 1762
1752	Le Monnier	Observations of air charge	Mem. de Paris, 1752
1752	De Romas	Observations of air charge; kite experiments	Mem. Sav. Etrange II., 1752
1752	Mylius Ch	Observations of air charge	8vo., Berlin, 1752.
1752	Kinnersley	Observations of air charge	Franklin's Letters, Phil. Trans., 1763, 1773
1752	Ludolf and Mylius	Observations of air charge	Letter to Watson
1753	Richman	Electrical gnomon	Phil. Trans., 1753
1753	Canton	Electricity of clouds	Phil. Trans., 1753
1753	Beccaria, C. B.	Systematic observations with an electroscope	Lett. del Elet. Bologna, 1758
1754	Lining	Kite experiments	Letter to Chas. Pinckney
1753	Wilson	Experiments	Phil. Trans., 1753, p. 347
1755	Le Roy	Experiments	Mem. de Paris, 1755
1756	Van Musschenbroek	Kite experiments	Intro. ad Phil. Nat., 1762
1759	Hartmann	Origin of electricity	
1769	Cotte	Memoirs on meteorology	Journ. Phys., xxiii., 1783
1772	Roynane	Fog observations	Phil. Trans., 1772
1772	Henley	Quadrant electrometer	Phil. Trans., 1772
1775	Cavallo	Fogs, snow, clouds and rain; kite experiments	Treatise on Elec., 1777
1784	De Saussure	Observations	Voyage dans les Alpes
1786-7	Mann	Daily observations with an electrical machine, timing the revolutions to produce a given spark with a record of the weather	
1788	Volta	New electroscope	Lettere Sulla Meteor, 1783
1788	Crosse	Experiments with collectors	Gelb. Ann., Bd. 41
1791	Reed	Insulation and conductors	Phil. Trans., 1791
1792	Von Heller	Observations	Green's Jour. d. Phys., 2 Bd., 4
1792	Schubler	Observations with weather rod	J. de Phys., lxxxiii

* Ueber die Ursache und die Gesetze der atmospharischen Electricitat. Von Prof. Franz Exner. Repertiorum der Physik. Band xxii. Heft 7.

† Ueber Atmospharischen und Gewitter Electricitat. Meteor. Zeits. 1, 2, 3 and 4, 1885.

‡ Memoir of National Academy of Sciences.

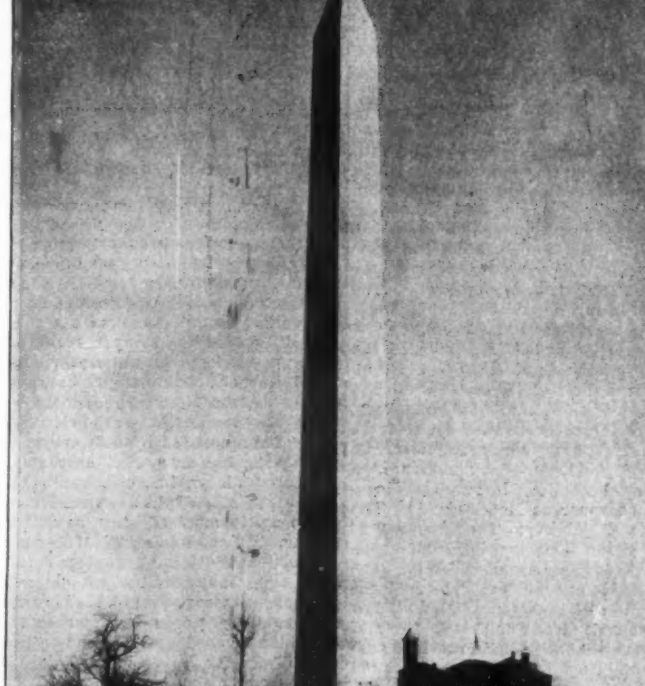
§ (a) Report of Chicago Meteorological Congress. Part II. August, 1893. (b) Zusammenstellung der Ergebnisse neuerer der Arbeiten uber atmospharische Electricitat. Von J. Elster und H. Geitel. Wissen. Beilage zum Jahresbericht des Herzoglichen Gymnasiums zu Wolfenbuttel, 1897.

‖ (a) Observations of Atmospheric Electricity. American Meteorological Journal. 1887. (b) Terrestrial Magnetism. December, 1897.

At the beginning of the nineteenth century, Schubler, at Tubingen, systematically observed for twenty years and worked out a curve of diurnal variation. Double maxima and minima were determined; the first maximum about 8 A. M., and the second about 8 P. M. The minima occurred before sunrise and about sunset. Correlating the values with weather conditions, Schubler found in 110 cases of rain, sixty-three negative values and forty-seven positive ones; while in thirty-three cases of snow, twenty-seven were positive and six negative.

Peltier's modification of the electroscope and his views on the origin of atmospheric electricity led to a series of observations by A. Cuetelet, beginning in August, 1842, at the observatory at Brussels. After some improvements in the electroscope were made, another set of observations was made in 1844, and it appeared that no negative values were observed except during rain. Indeed, negative values were rare, only twenty-three cases being recorded in four years. Passing the observations made at Dublin by Clark, in 1830, we come to those made at the observatory at Munich by Lamont, in 1850-51, with a Peltier electrometer and methods about the same as at Brussels. The monthly and annual means are given in Poggendorff's Annalen, lxxxv., 1852, pp. 494-504, and lxxxix., p. 258, *et seq.* In general, the winter months show a value nearly twice that of the summer months. About the same time, observations were made at Kreuznach by Dellmann. The yearly values nearly agree, but the mean monthly values differ considerably. A minimum occurs in May and a maximum in December. The air was generally positively electrified. Smoke and fog gave high positive values, and dust caused a change

WIRELESS STATION, SOUTHEAST FARALLON, WHICH RESPONDS TO THUNDERSTORMS IN SIERRA, 175 MILES DISTANT.



WASHINGTON MONUMENT. STRUCK JUNE 5, 1885, AND SUBSEQUENTLY.

from positive to negative for several hours and to a degree exceeding positive. Rain gave sometimes high positive and sometimes high negative, the latter often when the rain had just ended. Snow almost always gave high positive.

Everett, at Windsor, N. S., made observations, generally three per day, and the results of these and later observations have been widely published, and are too well known for extended notice now. During the same time, Wislizenus, at St. Louis, Mo., made observations, and has given the annual and diurnal curves of these. Two maxima and two minima are shown in the diurnal curve, and a maximum in winter. In all, Wislizenus made some 25,000 observations, and his conclusions are therefore of more weight than those of any other observer up to that time. The normal state of the air is positive, and negative is an exceptional and temporary condition. Marked disturbances were experienced at times of thunder storms. Fog was occasionally accompanied by negative indications, but after fine drizzling rain, fog as a rule was accompanied by positive values, often very high. A full discussion of the observations may be found in the American Meteorological Journal for 1887.

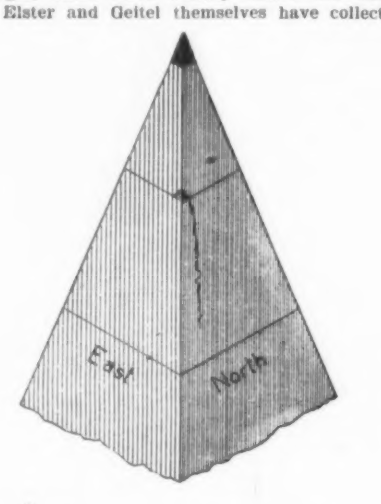
We have not space to do more than simply mention most of the other observers. W. A. Birt has given an elaborate discussion of the Kew Observations of 1845-1847 in the Report of the British Association, 1849, p. 113. At Gaud, Duprez studied the observations made from 1855 to 1864, and brings out particularly the relation to cloudiness. Palmieri, at Vesuvius, in 1850, and later with simultaneous observations at Naples and Vesuvius, found that the potential was lower at the higher station. In this conclusion he is at variance with all other observers. Some observations that are worthy of notice were made with a water-dropper collector at Pernambuco, from October, 1876, to February, 1877. On the rare occasions in which a negative potential was recorded, there were heavy rains and more or less cloudiness. We now come to the very important observations made at Paris by Mascart and others under his direction. The apparatus was installed at the College de France in February, 1878, and continuous records covering some years were obtained. In general, the potential of the air was positive. Rain was almost always accompanied by large negative values. The change in character occurs previous to the rain, and sometimes the rain is followed immediately by high positive values. A very full discussion of the observations made by the United States Signal Service is given in the Memoir of the National Academy of Sciences by Prof. T. C. Mendenhall. It is to be regretted that this discussion is not more generally known, for there are many valuable suggestions in it concerning mechanical collectors, best forms of electromotors, proper exposures, and details of methods to be followed, of great benefit to those who are to take observations. There is also an elaborate discussion of the question, "In the present state of meteorological science, can the observations of atmospheric electricity be utilized in forecasting the weather?" A very thorough set of observations was made by Muller and Leyst, in Russia, with a Carpentier form of Mascart electrometer. The mean values for bi-hourly observations made at Pawlowsk in 1884 are given in Annalen des Phys. Cent. Obs., Part I., 1884. Other observations are those made by C. Mitchie Smith, in Madras, in 1883 and 1884; Abercromby, at the Peak on the Island of Teneriffe; Dr. Fines, at Perpignan, with photographic apparatus of the Mascart pattern, which were continued for a number of years. Roiti, Magrini, and Pasquilini have two years' complete records at Florence. Exner's extensive experiments on the potential gradient, Andree's observations near the Pole while on the Swedish expedition, and the work on the Sonnblick by Elster and Geitel, bring us down to the present state of the problem.

Recently experiments have been undertaken at Kew* to verify Exner's law, that a building reduces the potential of the air precisely as if it formed an integral part of the earth's surface. A portable electrometer was carried to five stations near the observatory, and the mean values of the several ratios found to be approximately constant. The meteorological elements are then discussed, and particularly the moisture, to see whether the potential gradient is so closely connected with the aqueous vapor as Exner claims. The results do not support the theory. The influence of bright sunshine in reducing the potential gradient, as shown by Elster and Geitel, seems more likely. The potential was lower after long sunshine. The evidence "in favor of a connection of high potential with low temperature is just about as strong as that in favor of a connection of high potential with little previous sunshine." Higher potential was found to be associated with higher pressure in the forenoon observations, but to a less marked degree in the afternoon observations. Adopting eleven miles as a limiting value of the wind velocity, it was found that with a mean velocity of 19.6 miles per hour there was a mean potential of 153, and with a mean velocity of 6.8 the mean potential was 175. The author does not seem to be aware of the observations made in the United States upon similar lines. An attempt was also made to investigate the relation of the potential to cyclonic and anti-cyclonic weather. In five cases out of the seven considered the mean potential for the anticyclonic condition exceeded that for the cyclonic. In Dr. Chree's words, "There is something to be said for the hypothesis; but individual occurrences of high potential in cyclonic weather and of low potential in anticyclonic weather were not infrequent."

* Observations on Atmospheric Electricity at the Kew Observatory. By C. Chree. Proc. Royal Soc., vol. lx.

The recent paper of J. Elster* and H. Geitel is a most comprehensive review of recent investigations in the subject. For painstaking and systematic study of the potential as influenced by water vapor, sunlight, dust, and height, it cannot be excelled.

The views of Von Bezold and Arrhenius concerning a photo-electric action of the solar radiation have been in part confirmed by these investigators. It has been experimentally shown that the sun's rays act on certain substances in such a way as to cause a loss of negative electricity. Our authors make the potential gradient vary with exposure to ultraviolet light. The marked disturbances occurring with precipitation are considered as disturbances of the normal field. They also think that Palmieri is right in his statement that whenever negative electricity is observed rain falls close by. Sohncke and Luvini have shown how dry ice crystals were positively electrified through friction with dust-formed water, and Maclean and Goto, and more recently Lenard and Kelvin, have discussed the electrification through falling water. "When water-drops strike on a fixed moist substratum or a larger water surface, the surrounding air at the time of impact shows itself as negatively electrified." And our authors think, with Lenard, that it is very probable that the negative values so prevalent during rainy weather are in part due to this. With the building of mountain observatories, the electric phenomena of the air, and more especially the silent discharges, come more readily under our observation. Elster and Geitel themselves have collected a



Aluminium tip weighing 100 oz
Nearly 9" high 5½" square at base
Height from ground 555 ft (169 metres)

Struck April 5th 1885 without damage
" June 5th " crack on North
face just under top stone, extend-
ing through the block in a line
nearly parallel to NE corner.

APEX OF WASHINGTON MONUMENT.

number of observations relating to the appearance of St. Elmo's fire on the Sonnblick. It would seem that the phenomena are closely connected with climatic conditions and are to be studied in their development precisely as thunderstorms.

Elster and Geitel have rendered a great service to future students of atmospheric electricity by clearly pointing out the difference between the normal field or fair-weather electricity and the *accidental* field, if it may be so called, when the electrical measurements are greatly influenced by dust, snow, clouds, precipitation, whirling air or smoke, spattering water, etc. "Certainly it is an improvement," they say, "to diminish the influence of the lower dusty strata of air through the employment of kites, as introduced by McAdie at Blue Hill, and later by Weber at Kiel, though it is questionable if the advantage is not too dearly bought by the impossibility of determining the height." Marked improvements have been made in kite methods since these words were written. Another important matter touched upon by our authors is the circulation of electricity from the earth into the atmosphere and back again to earth. Theories are not wanting, but experimental determinations are. It is not improbable that a link in the chain of processes may be the aurora, and investigations in this direction are therefore greatly desired. Through such will the relation between the electric and magnetic fields be brought out. The following problem is suggested for investigation: "*How are the magnetic elements and the electrical currents of the air related?*"

Prof. Schuster in a recent lecture† has given a most interesting *résumé* of the experimentation of Franklin's time with the modern lecture apparatus for studying the conduction of gases. The question of the breaking down of the air as an insulating medium is touched upon, and the effect of light and of the discharge itself considered. Electric sparks are liable to succeed each other along the same path, and Schuster thinks this points to a higher conductivity of the air along the path of the previous discharge. Schuster also thinks that the location of the positive charge, corresponding to the earth's negative charge, can only be ascertained through the agency of balloon and kite experiments. "Observations made up to heights of about 1,000 feet seem to indicate a strengthening of the electric field, i. e., the fall of potential per meter is greater at a height of, say, 200 meters than on the surface of the earth." The observations of Dr. Leonhard Weber and Dr. Baschin are referred to, the former as showing how the fall of potential at a height of 350 meters was six times that at the earth's level; and the latter showing that at a height of 3,000 meters no fall could be determined, while at 760, 2,400 and 2,800 meters, respectively, the fall in volts per meter was 49, 28, and 13, respectively. It seems, therefore, likely that the lines of force of the normal electric field of the earth end within the first 10,000 or 15,000 feet. Schuster advances the somewhat startling view that the semidiurnal variation of atmospheric electricity is connected with "the same circulation in the upper regions of the atmosphere which shows itself in the corresponding changes in pressure." He refers to Exner's formula:

$$P = \frac{A}{1 + kp_0},$$

where $A = 1{,}300$, $k = 13.1$, p_0 = pressure of aqueous vapor present, in centimeters, and P = the electric force; and notes the agreement between vapor pressures 0.23 and 0.05. It is the amount of vapor, and not the humidity, which controls. Elster and Geitel's ultra-violet radiation relation to electrification and amount of aqueous vapor present is also alluded to.

(To be continued.)

* Review of Recent Investigations in Atmospheric Electricity. By J. Elster and H. Geitel. Extract from Part II of the Report of the Chicago Meteorological Congress, August, 1893, pp. 510-522.

† "Atmospheric Electricity." Lecture delivered before the Royal Institution of Great Britain, February 22, 1895, by Prof. Arthur Schuster.

[Concluded from SUPPLEMENT No. 1580, page 25311.]

HISTORY OF THE STANDARD WEIGHTS AND MEASURES OF THE UNITED STATES.*

By LOUIS A. FISCHER.

CAPACITY STANDARDS.

THE units of capacity, namely, the wine gallon of 231 cubic inches, and the Winchester bushel of 2,150.42, were adopted, because, as intimated, they represented more closely than any other English standards the average of the capacity measures in use in the United States at the date of Mr. Hassler's investigation. The wine gallon was introduced as a wine measure into England in 1707 during the reign of Queen Anne, but it was abolished in 1824, when the new imperial gallon, containing 10 pounds of water, was made the standard. This last statement applies also to the bushel of 2,150.42 cubic inches. This bushel is the earliest English capacity measure of which we have any record, a copy of it made by order of Henry VII. being still in existence. But this bushel had also been abolished in England, it having been superseded by the bushel of 8 imperial gallons. Therefore neither the gallon nor the bushel adopted by the United States Treasury Department was in accord with the legal capacity standards of England, but they were smaller by about 17 per cent and 3 per cent, respectively, and these differences exist at the present time. Not only did they differ from the new standards in Great Britain, but they also differed from the discarded English standards from which they were derived, for the reason that Mr. Hassler selected the temperature of the maximum density of water, namely, 39.2 deg. F.[12] as the temperature at which the United States measures were standard, whereas their English prototypes were standard at 62 deg. F.

Such, then, were the fundamental standards adopted upon the recommendation of Mr. Hassler by the United States Treasury Department, and to which the weights and measures for the customs service were made to conform. The construction of the weights and measures for this purpose was pushed with almost feverish haste, and so well satisfied was Congress with the progress made that the following resolution was passed and approved June 14, 1836:

"Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he hereby is, directed to cause a complete set of all weights and measures adopted as standards, and now either made or in progress of manufacture for the use of the several custom-houses, and for other purposes, to be delivered to the governor of each State in the Union, or such person as he may appoint, for the use of the States, respectively, to the end that a uniform standard of weights and measures may be established throughout the United States."

While the act does not specifically adopt the standards above described, the practical effect of it was to make them the standards for the United States, inasmuch as the weights distributed to the States in accordance with the act were in almost every case adopted by the State legislatures soon after their receipt.

The act of 1836 was supplemented in 1838 by a joint resolution of Congress, which directed the Secretary of the Treasury to furnish balances to the States. By 1838 the weights for the States were reported finished.

* An address delivered before the First Annual Meeting of the Sealers of Weights and Measures of the United States at the Bureau of Standards, Washington, D. C., 1905.

[12] According to the determination made by Mr. Hassler on the expansion of water, 39.83 degrees Fahr. was the temperature of maximum density. See report of Alexander D. Bache, Superintendent of Weights and Measures, 46-47. Ex. Doc. No. 73, 30th Cong., 1st sess.

and during the following year the weights for the custom houses were completed and delivered.[13]

By 1850 practically all the States admitted to the Union had been supplied with complete sets of weights and measures, and in addition sets were presented to England, France, Japan, and Siam. As new States were admitted they were also supplied with sets of standards, the last set being supplied to North Dakota in 1893.

In order to carry out the provisions of the acts of 1836 and 1838 the Office of Weights and Measures, under the direction of the superintendent of the Coast Survey, had been established, and all the standards adopted at the beginning of the work, and subsequently, were in charge of this office, with the exception of the troy pound of the mint, which has always remained at Philadelphia.

In October, 1834, the British imperial yard and troy pound made in 1758, of which the Troughton scale and the mint pound were supposed to be exact copies, were destroyed by the burning of the Houses of Parliament. When the new imperial standards to replace them were completed in 1855, two copies of the yard, and one copy of the avoirdupois pound were presented to the United States, arriving in this country in 1856. One of these bars, namely, bronze yard No. 11, was very soon after compared with the Troughton scale, the result showing that the accepted 36 inches of the Troughton scale was 0.00087 inch longer than the British imperial yard.[14] The second bar received from England was subsequently compared with the Troughton scale and fully corroborated the result obtained from the comparison with bronze No. 11. The new yards, and especially bronze No. 11, were far superior to the Troughton scale as standards of length, and consequently they were accepted by the Office of Weights and Measures as the standards of the United States, and all comparisons were afterward referred to the imperial yard through these two standards. They were twice taken to England and recompared with the imperial yard, once in 1876 and again in 1888.

The avoirdupois pound presented with the two yards was also compared with the United States avoirdupois pound derived from the mint pound, the result showing a very satisfactory agreement. The advent of the new pound did not, therefore, disturb the position of the troy pound of the mint or of the avoirdupois pound derived from the mint pound.

METRIC SYSTEM.

The next and perhaps the most important legislation enacted by Congress was the act of 1866 legalizing the metric system of weights and measures in the United States. The act, which was passed July 28, 1866, reads as follows:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system, and no contract or dealing or pleading in any court shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

"Sec. 2. And be it further enacted, That the tables in the schedule hereto annexed shall be recognized in the construction of contracts and in all legal proceedings as establishing in terms of the weights and measures now in use in the United States the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining and expressing in customary weights and measures the weights and measures of the metric system."

MEASURES OF LENGTH.

Metric Denominations and Values.		Equivalents in Denominations in Use.	
Myriameter,	10,000 meters	6.2137	miles
Kilometer,	1,000 meters	0.62137	miles, or 3,280 feet and 10 in.
Hectometer,	100 meters	328	feet and 1 in.
Dekameter,	10 meters	393.7	inches
Meter,	1 meter	39.37	inches
Decimeter,	1/10 of a meter	3.937	inches
Centimeter,	1/100 of a meter	0.3937	inch
Millimeter,	1/1000 of a meter	0.0394	inch

MEASURES OF SURFACE.

Metric Denominations and Values.		Equivalent in Denominations in Use.
Hectare	10,000 square meters	2.471 acres
Are	100 square meters	119.6 square yards
Centare..	1 square meter	1,550 square inches

While the above act was being considered, Congress also considered a resolution authorizing the Secretary of the Treasury to furnish the States with metric weights and measures. Strange to say, this resolution, which logically should follow, was approved one day before the act legalizing the use of the metric system. It was a joint resolution, and read as follows:

"Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he is hereby, authorized and directed to furnish to each State, to be delivered to the governor thereof, one set of standard weights and measures of the metric system for the use of the States, respectively."

The work of making and adjusting these standards fell, naturally, upon the Office of Weights and Measures, and the first question that had to be considered was that of standards. The practice followed by other countries which had adopted the metric system, of accepting the meter and the kilogramme of the archives of France as fundamental standards, was followed by the United States. The question was mainly one of securing authentic copies of these standards. Fortunately, the Office of Weights and Measures had several copies of both standards of more or less authenticity on hand, but without hesitation an iron bar, known as the "committee meter," and a platinum kilogramme, known as the "Arago kilogramme," were selected.

COMMITTEE METER.

The committee meter is one of fifteen similar bars, whose lengths were ascertained in the process of constructing the original meter by the French committee of weights and measures in 1799; hence its name, "committee meter."

The committee referred to was composed of members of the National Institute of France and of deputies from foreign countries. J. G. Tralle, the deputy from the Helvetic Republic, had been placed in charge of the construction of the meters, and when the bars were distributed among the members of the committee he secured two of them, one of which he presented to Mr. Hassler. This bar was therefore of the highest authenticity. As before stated, it is made of iron, with a cross-section of 9 by 29 millimeters, and its length is defined by the end surfaces, which are remarkably plane, when one considers the age in which the bars were made. The bar bears the stamp of the committee, namely, a small ellipse, whereof three quadrants are shaded and the fourth one clear, except for the number 10,000,000, which indicates the number of meters in a meridian quadrant of the earth. It also bears the mark :. at one end, by which it was distinguished during the comparison with the other meters. In Mr. Hassler's report on the construction of the meters[15] it is stated, on the authority of Mr. Tralle, that all the meters agreed with the true meter within one-millionth part of the toise.[16]

When Mr. Hassler came to the United States in 1805 he brought with him the committee meter, which he soon after presented to the Philosophical Society of Philadelphia, Pa. Shortly after, when he was put in charge of the survey of the coast, the meter was placed at his disposal by the Philosophical Society, and he made it the standard of length for that work, and until 1890 all base measurements of the survey were referred to this meter.[17]

In view of the foregoing, it was but natural that this bar should be selected as the standard to which the State meters should conform.

ARAGO PLATINUM KILOGRAMME.

The Arago kilogramme was procured in 1821 by Mr. Gallatin while minister of the United States to France, and was sent to this country, together with a platinum meter. The certificate of Arago, the celebrated physicist, which accompanied these standards, states that the kilogramme differs from the original kilogramme des Archives by less than 1 milligramme. The weight is a platinum cylinder with flat bases, the edges being slightly rounded. The height and diameter are nearly equal, being approximately 39.5 millimeters each. There is no stamp or distinguishing mark of any kind, except near the center of one base there is a faint lathe or tool mark of circular form. The weight is contained in a square mahogany box, on the cover of which is a circular silver plate bearing the inscription: "Kilogramme comparé pour son Poids a l'Etalon Prototype des Archives de France, et verifié par M. Arago. Fortin fecit." No particulars of Arago's comparison with the kilogramme des Archives were furnished, and consequently it is not known what means were used by him in making his comparison, nor whether he reduced his weighings to vacuo. It was not until 1879 that the Arago kilogramme was compared with any other standards of recognized authority. It is true that it was compared between 1852 and 1873 with a couple of kilogrammes in the possession of the Office of Weights and Measures, but as both of these weights were of brass and of unknown density, no great reliance could be attached to the results. In 1879, however, it was taken to England and there compared with the British platinum kilogramme in the custody of the Standards Office. This comparison indicated that the Arago kilogramme was 4.25 milligrammes light; but this result could not be considered conclusive, on account of certain assumptions made in the reduction to vacuo and also in regard to the correction to the British kilogramme.

In 1884 the weight was taken from the Standards Office in London, where it had been since 1879, to the International Bureau of Weights and Measures at Paris and there compared with two auxiliary kilogrammes whose values in terms of the kilogramme of the Archives were known with the greatest accuracy. The results obtained from the comparison confirmed that previously obtained from the comparison with the British kilogramme, the result giving

$$Ka = 1{,}000 \text{ g.} - 4.63 \text{ mg.}$$

As the weights supplied to the States were to be made of brass, it was more convenient to compare them with a brass standard, and in order to do this two secondary brass standards were carefully compared between the years 1873 and 1876 with the Arago kilogramme, and afterward used in all the work of adjustment and verification. One of the kilogrammes, known as the Silberman kilogramme, was presented to the United States by France in 1852, together with a number of other weights and measures. The other kilogramme used was one made in the Office of Weights and Measures, and was identical in form and material with the kilogrammes subsequently furnished to the States.

MEASURES OF CAPACITY.

Metric Denominations and Values.			Equivalents in Denominations in Use.	
Names.	Number of Liters.	Cubic Measure.	Dry Measure.	Liquid or Wine Measure.
Kiloliter or stere	1,000	1 cubic meter	1.308 cubic yards	264.1700 gallons.
Hectoliter	100	1/10 of a cubic meter	2 bushels and 3.35 pecks	26.4170 gallons.
Dekaliter	10	10 cubic decimeters	9.08 quarts.	2.6417 gallons.
Liter	1	1 cubic decimeter	0.908 quart	1.0567 quarts.
Deciliter	1/10	1/10 of a cubic decimeter	6.1022 cubic inches	0.8450 gill.
Centiliter	1/100	10 cubic centimeters	0.6102 cubic inch	0.3380 fluid ounce.
Milliliter	1/1000	1 cubic centimeter	0.061 cubic inch	0.2700 fluid drachm.

WEIGHTS.

Metric Denominations and Values.			Equivalents in Denominations in Use.
Names.	Number of Grammes.	Weight of What Quantity of Water at Maximum Density.	Avoirdupois Weight.
Millier or Tonneau	1,000,000	1 cubic meter	2,204.6000 pounds.
Quintal	100,000	1 hectoliter	220.4600 pounds.
Myriagramme	10,000	10 liters	22.0460 pounds.
Kilogramme or kilo	1,000	1 liter	2.2046 pounds.
Hectogramme	100	1 deciliter	3.5274 ounces.
Dekagramme	10	10 cubic centimeters	0.3527 ounce.
Gramme	1	1 cubic centimeter	15.4320 grains.
Decigramme	1/10	1/10 of a cubic centimeter	1.5432 grains.
Centigramme	1/100	10 cubic millimeters	0.1543 grain.
Milligramme	1/1000	1 cubic millimeter	0.0154 grain.

The unit of capacity in the metric system being defined as the volume of the mass of 1 kilogramme of pure water at the temperature of maximum density, the most convenient way to adjust such measures, and in fact all capacity measures, is by weighing the water they contain. The only two material standards that need to be considered, therefore, in connection with the metric weights and measures furnished to the States in accordance with the act of 1866, are the committee meter and the Arago kilogramme described above.

By the end of 1880 practically all the States had been supplied with sets of metric weights and measures consisting of the following denominations:

Length measures	1 brass-line meter. 1 steel-end meter.
Capacity measures	1 liter made of brass. 1 decaliter made of brass.
Weights	1 myriagramme of brass. 1 kilogramme made of brass. 1 half-kilogramme made of brass. 1 gramme made of brass. 1 set of small silver weights from 4 decigrammes to 1 milligramme.

It is necessary at this point to go back a few years and give an account of the establishment of the International Bureau of Weights and Measures, since the present fundamental standards of length and mass for practically the whole civilized world result from the establishment of that institution.

[13] H. R. Doc. 159, 28th Cong., 2d sess.

[14] See Report of the Secretary of the Treasury on the construction and distribution of weights and measures in 1857. S. Doc. No. 27, 34th Cong., 3d sess.

[15] H. R. Doc. No. 299, 22d Cong., 1st sess., pp. 75, 76.

[16] The toise was the French standard of length prior to the adoption of the meter, and all the geodetic measurements upon which the meter was based were made with the toise. Its length is 1.949+ meters.

[17] Special Publication No. 4, U. S. Coast and Geodetic Survey.

In response to an invitation of the French government, the following countries sent representatives to a conference held in Paris on August 8, 1870, to consider the advisability of constructing new metric standards: Austria, Ecuador, France, Great Britain, Greece, Italy, Norway, Peru, Portugal, Russia, Spain, Switzerland, Turkey, United States, Colombia; in all, fifteen countries. This conference was of short duration, on account of the war then raging between France and Germany.

A second conference was held two years later, at which thirty countries were represented, the United States again being among this number. At this conference it was decided that new meters and new kilogrammes should be constructed to conform with the original standards of the Archives, and a permanent committee was appointed to carry out this decision. The preparation of the new standards had advanced so far by 1875 that the permanent committee appointed by the conference of 1872 requested the French government to call a diplomatic conference at Paris to consider whether the means and appliances for the final verification of the new meters and kilogrammes should be provided, with a view to permanence, or whether the work should be regarded as a temporary operation.

In compliance with this request a conference was held in March, 1875, at which nineteen countries were represented, the United States as usual being of the number.

On May 20, 1875, seventeen of the nineteen countries represented signed a convention which provided for the establishment and maintenance of a permanent International Bureau of Weights and Measures to be situated near Paris, and to be under the control of an international committee elected by the conference, the committee to consist of fourteen members, all belonging to different countries.

In addition to the primary work of verifying the new metric standards the bureau was charged with certain duties, the following being the most important:

(1) The custody and preservation, when completed, of the international prototype and auxiliary instruments.

(2) The future periodic comparison of the several national standards with the international prototypes.

(3) The comparison of metric standards with standards of other countries.

The expenses of the bureau were to be defrayed by contributions of the contracting governments, the amount for each country depending upon the population and upon the extent that the metric system was in use in the particular country.

In accordance with the terms of the convention the French government set aside a plat of ground in the park of St. Cloud, just outside of Paris, and upon this ground, which was declared neutral territory, the International Bureau of Weights and Measures was established.

The construction of the meters and kilogrammes had been intrusted to a special committee, and early in 1887 the committee completed its work and the new meters and kilogrammes were turned over to the International Bureau for comparison with the standards of the Archives and with one another.

It had been decided as early as 1873 that the new standards should be made of an alloy of 90 per cent platinum and 10 per cent iridium, and that the meters should be line standards. Altogether 31 meters and 40 kilogrammes were constructed. By 1889 the entire work was completed, and in September of that year a general conference was held in Paris, and by it the work of the international committee was approved.

The meter and kilogramme which agreed most closely with the meter and kilogramme of the Archives were declared to be the international meter and the international kilogramme. These two standards, with certain other meters and kilogrammes, were deposited in a subterranean vault under one of the buildings of the International Bureau, where they are only accessible when three independent officials with different keys are present. The other standards were distributed by lot to the various governments contributing to the support of the International Bureau. Those falling to the United States were meters Nos. 21 and 27, and kilogrammes Nos. 4 and 20.

Meter No. 27 and kilogramme No. 20 were brought under seal to this country by George Davidson, of the Coast and Geodetic Survey, and on January 2, 1890, they were opened at the White House, and accepted by President Harrison, who certified that they were received in good condition, and that he confidently believed that they were the standards referred to in the report. The other two standards were received the following July, and were deposited in the Office of Weights and Measures, where those accepted as national standards by the President had already been taken.[18] On April 5, 1893, the Superintendent of Weights and Measures, with the approval of the Secretary of the Treasury, decided that the international meter and kilogramme would in the future be regarded as the fundamental standards of length and mass in the United States, both for metric and customary weights and measures.

This action did not in any way affect the metric weights and measures of the United States, inasmuch as the meter and kilogramme of the Archives had always been regarded as our fundamental metric standards, and the international meter and kilogramme had identical values so far as could be determined by the most refined measurements.

The effect of this decision on the customary weights and measures also left them practically undisturbed. All comparisons made immediately prior to 1893 indicated that the relation of the yard to the meter fixed

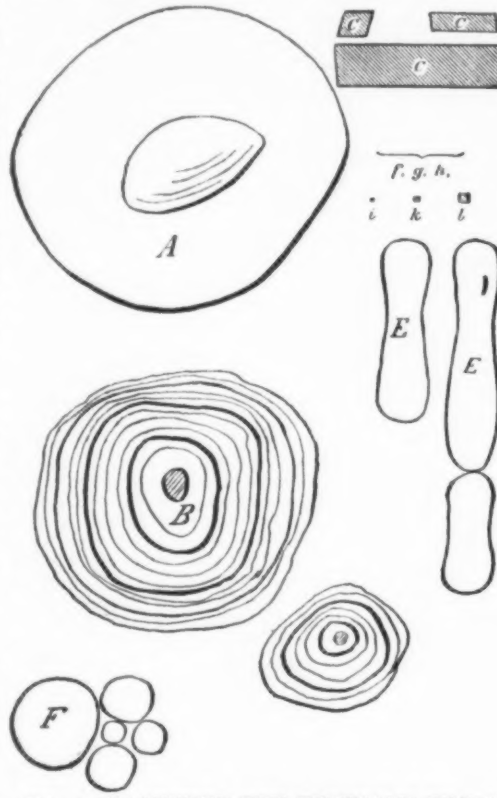


FIG. 1.—MAGNIFIED TEN THOUSAND TIMES.

A. Human blood corpuscle. *B.* Rice starch grain. *C.* Kaolin suspended in water. *E, F.* Bacteria. *f, g, h.* Particles of a colloidal solution of gold. *i, k, l.* Particles of a gold solution in the act of precipitation.

by the act of 1866[19] was by chance the exact relation between the international meter and the British imperial yard within the error of observation. A subsequent comparison made between the standards just mentioned indicates that the legal relation adopted by Congress is in error by one ten-thousandth of an inch; but in view of the fact that certain comparisons made by the English Standards Office between the imperial yard and its authentic copies show variations as great, if not greater than this, it cannot be said with certainty that there is a difference between the imperial yard of Great Britain and the United States yard derived from the meter.

The case of the pound was slightly different, inasmuch as the relation of the kilogramme to the pound, fixed by the act of 1866, was only approximate. In the act mentioned the kilogramme was stated to be equal to 2.2046 pounds avoirdupois; but as 2.204622 was known to be a more precise value, and since it did not

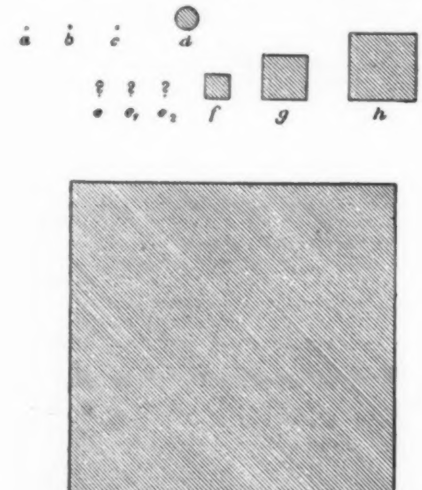


FIG. 2.—MAGNIFIED ONE MILLION TIMES.

a. Molecule of water. *b.* Molecule of alcohol. *c.* Molecule of chloroform. *d.* Molecule of soluble starch. *e-h.* Particles of colloidal solution of gold. *i.* Particles of gold in the act of precipitation.

conflict with the legal value, the avoirdupois pound was declared to be equal to 1/2.204622 kilogramme.

Neither the troy pound of the mint nor the copies of the imperial yard in the possession of the Office of Weights and Measures were satisfactory standards. The mint pound is made in two pieces, the knob being screwed into the body; hence its density cannot be determined by weighing in water on account of danger of leakage. Moreover, it is made of brass not plated, and therefore liable to alteration by oxidation.

The bronze yard No. 11, which was an exact copy of the British imperial yard both in form and material, had shown changes when compared with the imperial yard in 1876 and 1888 which could not reasonably be said to be entirely due to changes in No. 11. Suspicion as to the constancy of the length of the British standard was therefore aroused.

On the other hand, the new meters and kilogrammes represented the most advanced ideas of standards, and it therefore seemed that greater stability in our weights and measures, as well as higher accuracy, would be secured by accepting the international meter and kilogramme as fundamental standards.

Time has amply proved the wisdom of this action, and therefore when the Bureau of Standards was established, in July, 1901, the decision made by the Office of Weights and Measures in 1893 to adopt the meter and kilogramme as fundamental standards was fully accepted by this Bureau.

THE SIZE OF MOLECULES.

BY the term molecule the smallest possible particle of a chemical substance is understood. For example, if a piece of cane sugar is broken into smaller and smaller fragments, a point is finally reached beyond which the subdivision cannot be carried without producing something different from cane sugar. At this point we have reached the cane-sugar molecule.

Now, molecules are composed of atoms, which are the smallest possible particles of the chemical elements, and the dimensions of molecules vary greatly according to the number and character of the atoms of which they consist. The hydrogen molecule is a very small one, for it is composed of only two atoms of hydrogen. The molecule of cane sugar is comparatively large, containing 12 atoms of carbon, 22 of hydrogen and 11 of oxygen. But there are molecules of much greater size. The molecule of albumen is believed to contain nearly 1,000 atoms.

The subdivision of a lump of sugar, described above, is purely hypothetical, but many substances can be so divided very easily by dissolving them in water or some other liquid. In solution they are resolved either into separate molecules, as is the case with cane-sugar, or into larger or smaller groups of molecules. In the case of substances with very complex molecules especially, it must not be supposed that all the particles in the solution are equal in size; on the contrary, there are many reasons for believing that the groups of molecules are in various stages of disintegration.

The "ultra microscope," invented by Siedentopf and Zsigmondy, has made it possible to detect, in a solution, solid particles of a diameter of 4 millionths of a millimeter. (The limit of the best microscopes is 75 times as great, or 3 ten-thousandths of a millimeter.) This new optical instrument has brought the largest molecules, such as those of albumen and soluble starch, into the realm of visibility. The accompanying diagrams, from a recent publication* of Dr. Zsigmondy, may serve to give a vague idea of the dimensions of this ultramicroscopic world. If one of the largest of molecules, that of soluble starch, could be actually magnified 10,000 times in every direction, so that its volume would be multiplied 1,000,000,000, it would still be smaller than a pea. One of the five million corpuscles which are contained in a cubic centimeter of blood would, if enlarged in the same proportion, fill a large room, for its diameter would measure six meters.

In the SCIENTIFIC AMERICAN of November 11, 1905, some account was given of inorganic colloidal solutions, which consist of metals and other insoluble substances, in a state of extremely fine subdivision, held in suspension by water or other liquids. Zsigmondy has studied one of these solutions, colloidal gold, with especial care and has found that the suspended particles of gold differ very greatly in size.

SOME FACTS ABOUT YELLOW FEVER.

YELLOW fever is non-contagious, for in our medical literature numerous instances are recorded where numbers of patients were brought to certain places for treatment and no secondary cases resulted. This was before the days of disinfection, before any precautions were taken against mosquitoes, and at a time when intercourse with the sick was free and unrestricted. These strange occurrences were observed in Spain during a severe epidemic at Barcelona in 1821, during which, under the supposition that the air of the city was infected, there was a general exodus to the country. Here hundreds came down with the disease and were treated, but not a single case was recorded to have appeared in a person who had not visited the city. Yet tons of furniture and baggage were carried from infected houses into the country. All this took place in a warm climate and during the ravages of a devastating epidemic. Such remarkable occurrences were inexplicable mysteries that puzzled the most brilliant medical minds of the day; they could only be explained upon the theory that the air of the city had become contaminated. And so it had, but not with poisonous gases and noxious vapors as they supposed, but with infected mosquitoes. In the light of the mosquito theory the explanation is clear. An epidemic prevailed in Havana during the early part of that season, and a number of cases appeared on vessels after leaving there for the Spanish port, where the epidemic appeared later in the season. The first cases in Bar-

[18] Upon the establishment of the Bureau of Standards on July 1, 1901, all standards and other property in possession of the Office of Weights and Measures passed under the control of the Bureau.

[19] The value of the yard, in accordance with the above declaration, is 1 yard = 3600-3937 meter.

* Zur Erkenntniss der Kolloide, Jena, 1905, G. Fischer.

celona were seen on the vessels from Havana, lying in the harbor; then persons living in the city, but who had visited or were employed on the vessels, were taken sick; and later, the epidemic raged throughout various parts of the city. It is quite evident that the vessels carried infected mosquitoes as well as others that were not infected; these mosquitoes bred rapidly in the houses on shore and the conditions then became ripe for a rapid extension of the disease after the introduction of a few cases. It is to be noted that vessels were constantly arriving from Havana; cases appeared on the ships during the voyage, and, until suspicion was aroused, patients from the vessels were treated on shore. The *Stegomyiæ* introduced from the vessels, being house mosquitoes, remained in the city, while the country districts were free from them, and for that reason free from any extension of the fever. The absence of the proper mosquito is the only explanation that can be offered, and in the light of our present knowledge, it is all-sufficient.

In the United States, both before and since the epidemic at Barcelona, there have been similar outbreaks, always introduced by importation, though frequently regarded as of endemic origin, i. e., at Philadelphia, Baltimore, Norfolk, and New Orleans. In the latter city the danger is particularly great, because *Stegomyia*, being always present, it will readily spread the infection if it encounter a sufficient number of non-immunes.

Another good case in point is Petropolis, twenty-five miles from Rio de Janeiro, and at an elevation of 3,000 feet. Yellow fever is never known to occur there, spontaneously, and for that reason it has been made the home of non-immunes who spend the night at Petropolis and visit Rio during the day, for the transaction of business. While there are no *Stegomyiæ* at Petropolis, the French commission showed three years ago that the disease can be produced there by inoculation with infected insects. At the present day one who seeks can find abundant evidence to show not only that the mosquito transmits yellow fever, but that without the agency of the mosquito it is impossible to have yellow fever, except by means of experimental inoculations.

THE DISCOVERY OF POLARIZATION.

An infinite variety of polarization phenomena grew out of Bartholinus's (1670) discovery. Sound beginnings of a theory were laid by Huyghens ("Traité," 1690), whose wavelet principle and elementary wave front have persisted as an invaluable acquisition, to be generalized by Fresnel in 1821.

Fresh foundations in this department of optics were laid by Malus (1810) in his discovery of the cosine law, and the further discovery of the polarization of reflected light. Later (1815) Brewster adduced the conditions of maximum polarization for this case.

In 1811 Arago announced the occurrence of interferences in connection with parallel plane-polarized light, phenomena which under the observations of Arago and Fresnel (1816, 1819), Biot (1816), Brewster (1813, 1814, 1818), and others grew immensely in variety, and in the importance of their bearing on the undulatory theory. It is on the basis of these phenomena that Fresnel in 1819 insisted on the transversality of light waves, offering proof which was subsequently made rigorous by Verdet (1850). Though a tentative explanation was here again given by Young (1814), the first adequate theory of the behavior of thin plates of æolotropic media with polarized light came from Fresnel (1821).

Airy (1833) elucidated a special case of the gorgeously complicated interferences obtained with convergent pencils; Neumann in 1834 gave the general theory. The forbidding equations resulting were geometrically interpreted by Bertin (1861, 1884), and Lommel (1883), and Neumann (1841) added a theory for stressed media, afterward improved by Pockels (1889).

The peculiarly undulatory character of natural light owes its explanation largely to Stokes (1852), and his views were verified by many physicists, notably by Fizeau (1862) showing interferences for path differences of 50,000 wave-lengths and by Michelson for much larger path differences.

The occurrence of double refraction in all non-regular crystals was recognized by Haüy (1788), and studied by Brewster (1818). In 1821, largely by a feat of intuition, Fresnel introduced his generalized elementary wave surface, and the correctness of his explanation has since been substantiated by a host of observers. Stokes (1862, etc.) was unremittingly active in pointing out the theoretical bearing of the results obtained. Hamilton (1832) supplied a remarkable criterion of the truth of Fresnel's theory deductively, in the prediction of both types of conic refraction. The phenomena were detected experimentally by Lloyd (1833).

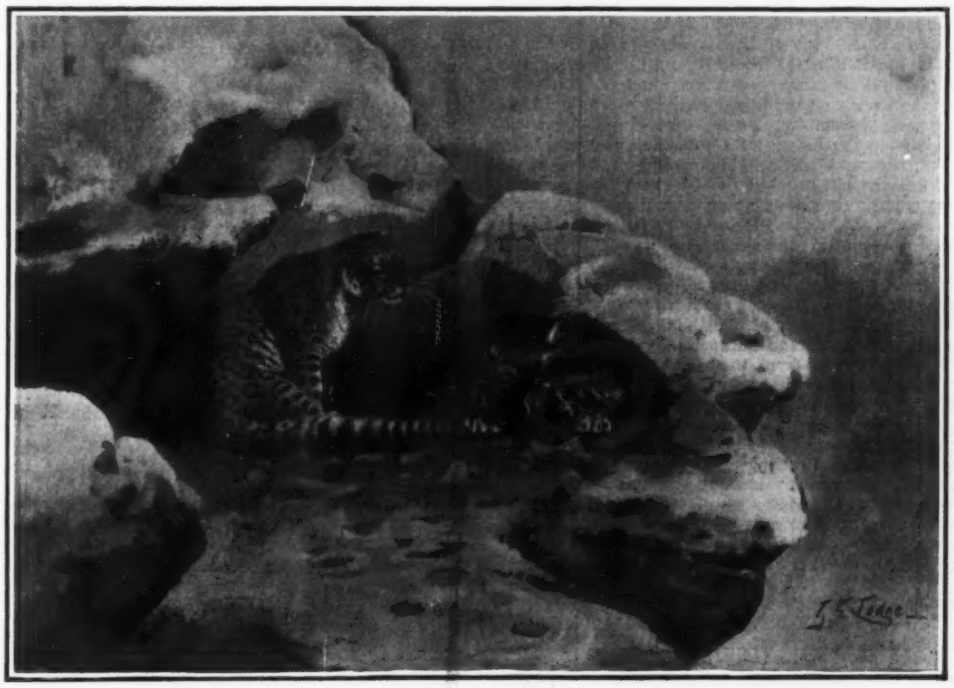
The domain of natural rotary polarization, discovered by Arago (1811) and enlarged by Biot (1815), has recently been placed in close relation to non-symmetrical chemical structure by Le Bel (1874) and Van 't Hoff (1875), and a tentative molecular theory was advanced by Sohncke (1876).

Boussinesq (1868) adapted Cauchy's theory (1842) to these phenomena. Independent elastic theories were propounded by MacCullagh (1837), Briot, Sarrau (1868); but there is naturally no difficulty in accounting for rotary polarization by the electromagnetic theory of light, as was shown by Drude (1892).

Among investigational apparatus of great importance the Soleil (1846, 1847) saccharimeter may be mentioned.

THE SNOW-LEOPARD OR OUNCE.

The existence of the snow-leopard has been known from an ancient date, though the creature was probably never seen by Europeans, if the name of "ounce" is to be credited to that animal. It was the subject of an odd mediæval legend. Any man bitten by an ounce was believed to be immediately attacked by mice, which were attracted to a person so bitten in a miraculous manner. A circumstantial account is given of the escape of a man so bitten, who baffled the mice by putting to sea in a boat! Buffon very properly put down the ounce as a separate species, and Bewick drew a figure of it in his "History on Quadrupeds," but the last part of his description is evidently intended for the cheetah. Col. Henry Smith saw a snow-leopard in the Tower menagerie before the collection was dispersed, and a by no means bad little engraving appeared in Knight's "Animated Nature," taken from a specimen brought to the British Museum in 1837. It was originally the property of a Col. Cobb, who made a large collection of Indian animals, and was exhibited as a great rarity before the Zoological Society. It was considered that its long fur most probably indicated that it was an inhabitant of cold and mountainous regions. It is now known that the snow leopard inhabits all the highest ranges of Central Asia, including the Altai and Thian Shan. It is not known how far east its range extends—possibly into Persia. But it is found in the mountains of North China, and apparently in the region of the Ameer. About a dozen fine skins were shown, probably from those parts, at Sir L. Lampson's fur sales last year. It is said that the new cavalry regiment for the sons of Indian nobles is to have trappings of snow-leopard skins, against which proposal more than one energetic protest has been raised. The leopard haunts the ground frequented by mountain sheep of various kinds, and accommodates its movements to those of its prey. Those brought to this country are remarkably gentle and tame. That kept at the Zoo recently would allow any stranger to stroke it, and the new one which has taken its place seems equally friendly.—Country Life (London).



SNOW-LEOPARDS.

WONDERS OF COMPLICATED HOROLOGICAL MECHANISM.

When the Cathedral of Lyons is visited, the sacristan who acts as cicerone never fails to arouse the admiration of strangers for the clock, declaring that it is the finest that ever was constructed. There may be a little exaggeration in this, for, besides the unrivaled clock of the Cathedral of Strasburg, several which have disappeared, but of which we retain descriptions, can be counted as marvels of mechanical art.

The most celebrated of these is the clepsydra presented by the Caliph Haroun-al-Rashid to Charlemagne. All historical works speak of it, and there are few children whose eyes have not opened wide on learning that the hours were struck by figures of cavaliers, who caused balls to fall upon a bell of gold. It can be imagined that the retinue of Charlemagne was confounded with astonishment on seeing this clepsydra, an invention then unique in Europe; but even at that time there were several mechanisms in the Orient, not less extraordinary, notably at Gaza, where there was a clock in which eagles of brass at every hour deposited a crown on the head of Hercules.

One, still more remarkable, existed in Africa, in the palace of the ancient kings of Tlemsem, a clock called "Mendzanah," which has been minutely described by the Arab historians. Above the case rose a bush, on which was perched a bird, with two birdlings under its wings. At the moment when the hour struck, a serpent glided from its lair, situated below the bush, and climbed up toward the two young birds to surprise them. Then two eagles intervened, and with their beaks caused a weight of copper to fall into a basin of the same metal; this weight penetrated the interior of the clock through a hole, and the hitting of the serpent, brought to the end of its course, could be heard. At the same time one of the dozen doors around the case opened, giving exit to a young slave, who saluted with the left hand, while with the right hand he presented a book on which the hour was inscribed. It must be acknowledged that this mechanism was sufficiently complicated to explain why the Arabians classed the Mendzanah among the marvels of that epoch.

However, the Occident soon became the scene of the *chefs-d'œuvre* of horology. A number of the large cathedrals during the fifteenth century were supplied with clocks more or less remarkable.

At Lund in Sweden there was one, admired for its mechanism, which was not inferior to the most famous clepsydras. Every sixty minutes two horsemen rushed at each other and gave as many strokes as there were hours to be sounded; then, a door opened, and within appeared a theater, where the Virgin Mary was seen seated on a throne with the Infant Jesus in her arms. The royal Magi advanced, followed by a troop of horsemen, and prostrated themselves before the Divine Child, offering their gifts, while two trumpets were sounded, ending the spectacle, which reappeared an hour later.

In our own days, there may be seen in France and abroad many curious clocks, which have resisted the course of decay and destruction. Among these may be mentioned a number of Jacquemarts, statues of metal representing armed cavaliers, who sound the hours by striking a bell. The most celebrated are those at Dijon and at Lambesc in Provence. But the mechanism of these clocks is simple compared with that of the masterpieces to be seen at Lyons, Beauvais, and Strasburg.

The clock of the Cathedral of Lyons, which has been recently repaired, comprises a number of figures; an angel saluting the Virgin, the heads of two lions with moving eyes, and a chanticleer. It is furnished with a perpetual almanac, and an astrolabe, indicating the hours, the sun in its degree, and the movements of the moon.

The clock of the Bishopric of Beauvais is still more complicated, but it is quite modern. It is the work of M. Vérité, the engineer, who died in 1887. This astonishing clock is provided with 52 dials, designed to mark the hour, the day, the week, the month, the rising and setting of the sun, the phases of the moon, the tides, the time of the principal cities of the world, and a series of terrestrial and astronomical evolutions. It is composed of 92,000 pieces. A weight furnishes the motive power for this prodigious assemblage. The frame, of carved oak, is about 8 meters in height by 5 meters in width. When the hour is struck, a general movement is produced, and the whole edifice seems to be animated. The constructor wished to give an idea of the last judgment; the cock crows, the angels come from the four cardinal points at the sound of the trumpet, and flames issue from the openings of the bell towers on the right and the left. The Eternal Father inclines his head and makes a sign that he is to judge the world; a soul, that of an impenitent sinner, advances and appears before the sovereign judge, who condemns it to eternal punishment. A demon, armed with a fork, appears and precipitates the soul into the abyss. It is now the turn of the just soul to appear before the judge; the good that it has accomplished

on earth prevails for eternal felicity. The angels come and form a cortege of honor and conduct it triumphantly to heaven amid the sounds of sweet harmony. The clock of M. Vérité may be considered as the most remarkable in existence. Perhaps it may be placed in the same category as the celebrated astronomical clock of the Cathedral of Strasburg, the surpassing work of Schwelgué, the mechanical genius, who, charged in 1838 with restoring the old clock, which had been dumb from the year 1789, virtually made it into a new one, devoting a dozen years to the gigantic undertaking.

The Strasburg clock is too well known for much description. We will state briefly that it indicates the evolutions of the planets, the phases of the moon, the eclipses, and the apparent and the sidereal time. On the nights of December 31 and January 1, a large company of personages are put in motion; but at noon every day it shows us the twelve apostles defiling before Jesus, angels turning an hour-glass, and a cock crowing at the top of the monument. Constructed by a Frenchman at the time when Alsace belonged to France, the Strasburg clock has remained French in spite of all the efforts of the German government. There is quite a difference between Paris time and that of Berlin. The clock of Schwelgué strikes Paris time. An attempt was made to impose on it the German time but it obstinately refused, and clockmakers have made reiterated attempts without success. The cock, in particular, remains recalcitrant. As soon as it is noon at Paris, he beats his wings and launches out his cock-a-doodle-do; he cannot be stopped without breaking the machine, and his tenacity has been triumphant. —Translated from the Revue Internationale de l'Horlogerie.

THE PRODUCTION OF INDUSTRIAL ALCOHOL AND ITS USE IN EXPLOSIVE MOTORS.

A favorable report on the free (denaturized) alcohol bill was authorized by the Committee on Ways and Means in Washington recently, and the advocates of the measure are consequently very hopeful that it will pass the House. The bill has been drawn by Chairman Payne, as a result of the hearings of the committee, and it is in the nature of a substitute for other bills, having the same object, which had been introduced.

The Payne bill provides in effect that from and after three months from its passage domestic alcohol of such degree of proof as may be prescribed by the Commissioner of Internal Revenue and approved by the Secretary of the Treasury, may be withdrawn from bond without the payment of internal revenue tax, for use in the arts and industries, and for fuel, light and power, provided such alcohol shall have been mixed (in the presence of an authorized government officer, before withdrawal from the bonded warehouse) with a denaturizing material suitable to the use for which the alcohol is withdrawn, but which destroys its character as a beverage. The character and quantity of the denaturing material and the conditions upon which the alcohol may be withdrawn free of tax are to be prescribed by the Commissioner of Internal Revenue, who shall make all necessary regulations for carrying the proposed law into effect.

A penalty of not less than $5,000 fine or five years' imprisonment, or both, is provided for violations of the law in using such tax-free alcohol in the manufacture of any beverage or liquid medicinal preparation. An appropriation of $250,000 is provided for carrying the proposed law into effect.

At the hearings of the Committee on Ways and Means many expert witnesses were examined as to the uses of alcohol, and many interesting facts and figures were brought out. L. B. Goebbels, of the Otto gas engine works, which builds great numbers of internal combustion engines, principally for stationary purposes, said that three years ago the increasing cost of gasoline compelled the Philadelphia house concern to look for a substitute fuel, and he had made a trip to Germany to inquire into the use of denaturized alcohol.

"I had occasion to take part in several shop tests made with alcohol engines, which varied in size from 10 to 30 horse-power," he testified. "The results which we obtained showed that out of an engine of a given size—that is, a given cylinder capacity—we got an average of 20 per cent more power than out of the same size engine operated on gasoline. This is due to the fact that while alcohol does not have the same heating value per volume as gasoline, the proportion being about 1 to 1.6 in favor of gasoline, it is possible to get a higher efficiency from alcohol, because it can be compressed to a much higher degree without danger of spontaneous combustion than is possible with gasoline.

"The thermal efficiency, that is, the degree of utilizing all of the heating value of alcohol, is therefore much greater than that of gasoline, the figures being about 21 per cent for gasoline as against 30 per cent or more for alcohol.

"A 10-horse-power engine was tested in the same condition in which it had previously run on gasoline, without any change whatever. It developed 11 brake horse-power, as against 10 horse-power with gasoline, and consumed 1½ pints of alcohol per horse-power per hour. By increasing the compression of the engine this consumption was reduced to 1.1 pints per horse-power per hour. There was no difficulty in starting the engine on alcohol, even when cold. This was particularly important to determine, as in the German engines which I have tested it was necessary to start the engine on gasoline and turn on the alcohol after the engine had warmed up, which took about two or three minutes.

"A 15-horse-power, of which I have a test record, shows similar results, the power developed being 16.5, as against 15.2 with gasoline, while the fuel consumption was 1.08 pints per brake horse-power per hour."

A few preliminary tests were made to compare the rate of evaporation and danger of explosion of gasoline and alcohol. First, a surface about 6 inches square was covered with equal volumes of gasoline and alcohol. The alcohol took twice as long to evaporate. Second, a small quantity of gasoline in a receiver placed in any part of an iron bucket had at the end of half an hour filled the bucket with explosive mixture, so that a lighted match placed anywhere in the bucket caused an explosion. The same experiment tried with alcohol failed entirely, although the alcohol was allowed to stand a longer time. Two things tend to account for this. Even dilute mixtures of gasoline vapors and air are explosive, and gasoline vapor, being much heavier than air, diffuses upward very slowly, thus keeping the mixture near the liquid rich enough to be explosive.

Mr. Goebbels said his concern had built a number of engines of 160 horse-power each for use in submarine boats. In connection with those for the United States navy the question arose as to the danger of using gasoline, and a trial was made, which demonstrated that alcohol could be used in the motor without any structural change. The motor was first started on gasoline, and after a half hour's run the gasoline was shut off and alcohol turned on.

"There was no change then in the amount of power developed," continued Mr. Goebbels, "but the fuel supply valve had to be opened a little more, increasing the consumption from 0.110 gallon to 0.130 gallon per horse-power. The engine was then shut down after a two-hour run, allowed to cool off, and was started on alcohol and run for another period of one hour. It was then taken apart and the cylinder valves and interior portions of the engine were carefully examined. It was shown that parts exposed to the combustion were as free from rust or sediment as they generally are when using gasoline.

"I have also examined the interior portions of alcohol engines that have been in continuous use for three years, and have found them to be in good working order, except such wear as necessarily takes place in all internal-combustion engines."

At the opening of the hearing Secretary of Agriculture James Wilson spoke in favor of the bill, and gave some figures as to the possible sources of supply of materials for producing alcohol:

"An acre of land which produces 50 bushels of corn, nearly 2,800 pounds, will furnish 1,960 pounds of fermentable matter; that is, starch and sugar together. Forty-five per cent of this will be obtained as absolute alcohol, namely, 882 pounds. A gallon of absolute alcohol weighs 6.8 pounds; therefore an acre of corn would produce about 130 gallons of absolute alcohol. Commercial alcohol is about 95 per cent pure, so that approximately an acre of Indian corn producing 50 bushels would make about 140 gallons of commercial alcohol.

"If we assume the average crop of potatoes to be 300 bushels, or 18,000 pounds, it would produce 3,600 pounds of fermentable matter, since the potato contains an average of 20 per cent of this material. This would produce 1,620 pounds of absolute alcohol, or about 255 gallons of commercial alcohol, showing that an acre of potatoes produces much more alcohol than an acre of corn."

By using a grade of potatoes especially for alcohol production the output could be increased to 500 gallons of alcohol to the acre.

Commissioner of Internal Revenue John W. Yerkes, when questioned about the methods employed to denaturize alcohol, explained:

"The denaturizing material generally used is wood alcohol, and to that is added either a bone oil, which is not fragrant, or some one of the coal-tar preparations, with pyridine bases, say four parts of wood alcohol and one part of pyridine base. I understand that it is the crude wood alcohol that is used and not the refined and highly purified wood alcohol. They use a fixed quantity of these denaturizing materials, which are supposed to destroy the beverage qualities in two ways: First, by producing toxical poisoning qualities with the wood alcohol, and, second, by the disgusting flavor and perfume that you get from the thorough admixture of these elements. It is undoubtedly true that if you take alcohol in that condition, made non-potable, it is absolutely beyond the pale of ordinary use for beverage purposes."

N. Bachelder, representing a national organization of farmers, told the committee that 2½ gallons of 90 per cent alcohol could be produced from a bushel of corn. With corn costing 30 cents a bushel, alcohol could be produced for 11 or 12 cents a gallon, and with corn at 40 cents the cost would be about 16 cents. With an average cost to the distiller of 35 to 40 cents a bushel, alcohol could be sold for 20 cents a gallon.

In the West and Northwest gasoline is now sold for 20 to 25 cents a gallon. "As practically no gasoline is found in the petroleum obtained in California, Texas, and other States from which the largest proportion of our oil supply is secured, and as the production of Eastern petroleum is falling off each year," he said, "it is evident that in a short time the demand for gasoline will so far exceed the supply that its cost for motor fuel purposes will be prohibitive. It is therefore absolutely necessary that some alternative source of fuel supply should be secured, and the only satisfactory substitute which has been suggested is alcohol."

H. P. Mehlin, representing the piano interests of the country, testified that the present price of grain alcohol was about $2.50 a gallon, of which $2.08 was tax, leaving 48 cents for the cost of the alcohol, and wood alcohol cost in the neighborhood of 70 cents a gallon, though a few years ago it cost as low as 50 cents a gallon for 75 per cent spirit. The highest grade of wood alcohol, called "Columbian spirits," now costs about $1.35 a gallon.

The lighting value of grain alcohol was dicussed by R. F. Herrick, representing the American Chemical Society. He exhibited a French lamp fitted with a Welsbach mantel using gasified spirits. Tests made with the lamp demonstrated that one gallon of alcohol burned fifty-eight hours and fifty-two minutes, the candle-power of the lamp being 25, and the candle-power hours, 1,471. In a lamp burning kerosene one gallon lasted eighty-seven hours, the candle-power of the lamp being 9 and the candle-power hours, 783. He quoted Prof. Rosseau, of Brussels, who had made photometric tests of both alcohol and kerosene burning lamps, and who reported that for lighting purposes alcohol costing 31 cents a gallon was slightly cheaper than kerosene costing 15 cents.

In reply to a query Mr. Herrick said the boiling point of highly purified wood alcohol was about 64 deg. C., and of grain alcohol about 78 deg. C. Crude wood alcohol could be bought "around 35 to 40 cents a gallon."

Prof. C. E. Monroe told the committee that the production of wood alcohol in the United States in 1904 was 12,493,212 gallons, of a total value of $5,624,486.

There was some discussion about the possibility of illicit recovery of alcohol from untaxed denaturized alcohol in case the bill should become law. A statement was presented to the committee which had been made by Profs. Remsen, Chandler, and Parker, all eminent chemists, which says: "It is plain, from the foregoing, that, considering our experiments as final—that is, experiments on this very point—it is impossible to purify the mixture containing wood naphtha to a sufficient extent to make it palatable, without distillation, and hence apparently it would be as difficult to carry on the process of purification on a large scale as to carry on the illegitimate manufacture of alcohol."

James S. Capen, representing the Detroit Board of Commerce, was heard as to the probable demand for denaturized alcohol, especially for use as a fuel in internal-combustion motors. In the course of his remarks he said:

"As a power producer alcohol is about equal to gasoline. It is true that at present there is a little more difficulty in starting an engine with alcohol than with gasoline, but this will be soon overcome once you give to engine builders an incentive to overcome it; in fact, even now I think I can take you to a place where you can see a carbureter that will work with alcohol as well as those now in use work with gasoline.

"There is far more safety in the use of alcohol than in the use of gasoline, and the fact that a fire produced by alcohol is readily put out by water makes it especially attractive, as water only spreads and increases the danger from a gasoline fire. Then, too, with alcohol there is no use for a law that it cannot be drawn after dark by candle or lamp light.

"Cleanliness is another attractive feature in the use of alcohol. Cylinders and valves do not get clogged by the left-over products of combustion. Odors arising from it are scarcely perceptible and not unpleasant. There will be no need to have one boy play he was the gasoline smell, when our children are playing they are automobiles. In fact, the disagreeable features of gasoline are almost entirely absent from alcohol.

"To sum up, the reasons that alcohol is preferable to gasoline for power use are:

"First: It can be produced as cheaply, perhaps for less, within a short time.

"Second: There never will be any chance to advance its price on account of scarcity.

"Third: It is so much safer that one can almost say it is absolutely safe.

"Fourth: It is absolutely clean and sanitary.

"Fifth: If there is a leaky pipe in the bottom of your boat it can be so arranged that the alcohol can be made to mingle with the water, so that danger from fire or explosion is absolutely prevented."

Alcohol was largely used for lighting, cooking, fuel, and industrial purposes in the United States previous to the imposition of the prohibitive revenue tax. In 1864 Cincinnati alone utilized 12,000 bushels of corn a day for distillation. The production was enormous; with less than half the present population the annual production was 90,000,000 gallons, indicating that with the increased uses to which it is now put where untaxed, the agricultural interests would profit vastly from the greatly increased market for cereals, mainly corn. Alcohol is sold in South American countries and in Cuba at about 10 cents a gallon.

Its employment in automobiles, while it would doubtless necessitate radical modifications in present motor designs, especially in the carbureter, would be certain to appeal to the self-interest of the farmer, who would see in every passing machine a possible customer for farm products.—The Automobile.

A private syndicate has asked the Russian government for permission to make the preliminary surveys for a railway from Moscow to Nizhni Novgorod, which lies 265 miles to the east-northeast, and thence back in a northwesterly direction to Reval, the Esthonian port on the Baltic.

ENGINEERING NOTES.

In the welding of aluminium great difficulties have always been experienced in order to have a good weld and also to melt the metal without great loss. A new industrial welding process has been brought out in France by Odam & Company. The operation is carried out by the use of a special product which it seems has given very good results. Independently of the product which serves to make the welds and strong brazing, there are other special products which are used in making fine brazing. As to the melting of aluminium in ingots, scrap, sheet, filings, etc., it is obtained without loss by adding in the crucible a determined quantity of a special reducing substance. These different products have already been placed on the market in Paris.

The dam which has been constructed in the valley of the Urft, in the lower Rhine region, is no doubt the largest in Europe to be built for operating a turbine plant. It backs the water up in the valley so as to form a vast reservoir having over 50 million cubic yards capacity. The dam is built in the arc of a circle having 650 feet radius, and it is nearly 700 feet long at the base and 200 feet high, while the width is 150 feet. A tunnel, cut mostly in the rock, brings the water to a point above the turbine station, whence the penstocks run down to the wheels. The tunnel has an average section of 8 square yards, and the greatest height is 9 feet. Where it passes through the rock the tunnel is lined with beton 16 inches thick. In ordinary ground this is replaced by a masonry vaulting 30 inches thick. The turbines in the Heimbach plant are coupled to dynamos, and work under a 350-foot head of water. At present there are six turbines installed in the plant which are of the horizontal shaft type, and have a capacity of 2,000 horse-power each, working at 500 revolutions per minute. Other wheels are to be added in the near future, so as to bring the total output of the plant up to 17,000 horse-power or more. Turbines of Swiss make, built by Escher, Wyss & Co., are used here.

A new apparatus which will no doubt be a great improvement in connection with the rubber industry is a machine for rubber washing, a recent invention which is now being applied in the colonies. It is composed essentially of two horizontal steel cylinders which can be separated from each other as desired. The rubber, freshly coagulated, is placed between the two cylinders, whose axes have been fixed beforehand so as to leave but a small space between the cylinders. Different rates of speed are then given the two cylinders by gearing and belt transmission. The effect of this action is to stretch out and tear the rubber, which owing to its elasticity is thus freed from all the solid impurities, and under the continual pressure which is given to it, finally takes the form of a more or less hard and compact sheet. At the same time a stream of water is sent upon the surface of the cylinders and in this way all the soluble impurities are washed out. The final product which leaves the apparatus is a coherent and granular sheet, whose thickness varies with the space adjusted between the cylinders. Another machine is the invention of Messrs. Michie and Colledge. According to recent descriptions, it appears to give even more complete and better results in treating the rubber than the one just mentioned, seeing that it even allows of coagulating the milk. The latter is poured into a tank and comes out of the machine in the form of a white spongy matter from which the water is squeezed out just as from a veritable sponge. The rubber obtained in this way is put to dry in an ordinary drying oven at a temperature which should not exceed 95 deg. C. With this apparatus it is stated that rubber for the market can be prepared from the milk within 24 hours.

The use of straw as a fuel is a question which has been recently brought to the front on the Continent, and especially in France, where some interesting experiments have been made in this direction. Straw is difficult to sell, and farmers who are far from the railroads find it even impossible. The price has fallen considerably of late, and straw which sold on the farm for $10 per ton, within the last two years has dropped to $5 per ton delivered at Paris, which makes but $3.60 on the spot. Some means of utilizing the straw is to be sought for. It is found that for heating portable steam engines on the farm, for threshing machines, etc., it is not very advantageous, as we must use four times the weight of coal, which represents forty times the volume. In this way the straw only has a value of $2 per ton. M. Bordenave lately made some trials at Noisel for using straw in gas producers, and also other vegetable products. With a 70-horse-power plant he obtained a horse-power-hour with only 2.3 pounds of straw and a little less of hay. Allowing per horse-power-hour the sum of $0.01 for operating expenses and interest, and a value of $4.40 per ton for the straw, M. Bordenave figures that a horse-power-hour costs $0.0126 with wheat straw, and $0.0114 with oat straw. With the best portable steam engines, coal gives the horse-power-hour for $0.04, and petrol gives about the same. Electric motors run from a distant hydraulic plant give $0.16 to $0.02. Thus the gas-producer method seems to be the cheapest. In this way gas engines could be operated for many farm uses, and would be a great advantage. In some cases a certain number of farms could procure a 70-horse-power plant and use it in common. The results can be seen when we observe that we can replace nine pounds of coal (used in the steam engine) at $8 per ton by the gas from 2.3 pounds of straw.

SCIENCE NOTES.

After the searching criticism to which Poincaré, especially in his St. Louis address, in 1904, has subjected the foundations of mechanics and mathematical physics, almost the only one of the fundamental principles that appears to remain intact is the principle of least action. It seems, therefore, natural to take this principle as the starting point for a common foundation of mathematical physics and of a generalized mechanics, but with a broader definition of "action," or what amounts to the same, with a generalized conception of "mass" so as to make the latter a function of the velocity. A very notable attempt has recently been made in this direction by E. and F. Cosserat. And although only a first instalment of their investigation has so far been published, the able way in which the difficult problem is here attacked seems full of promise for a solution as complete as the nature of the case may warrant.

Soundings have been obtained over all parts of the seas, even in the two Polar seas; and, though much remains to be done, we can now form a very close approximation to the amount of water on our earth, while the term "unfathomable ocean" has been shown to have been based on an entire misconception. Biological research has also revealed a whole world of living forms at all depths, of the existence of which nothing was known before. The bulk of the ocean is about fourteen times as great as that of the dry land above water, and if the whole of that land were thrown into the Atlantic Ocean it would only fill one-third of it. Eleven years ago the greatest depth known was 4,700 fathoms, or 28,000 feet. We have since found several places in the Pacific where the depth is nearly 5,170 fathoms, or 31,000 feet, or somewhat higher than Mount Everest, which has been lately definitely shown to be the culminating point of the Himalayas. These very deep parts of the ocean are invariably near land, are apparently in the shape of troughs, and are probably due to the original crumpling of the earth's surface under slow contraction.

The physicist like the biologist and the historian, watches the effect of slowly varying external conditions; he sees the quality of persistence or stability gradually decaying until it vanishes, when there ensues what is called, in politics, a revolution. These considerations lead one to express a doubt whether biologists have been correct in looking for continuous transformation of species. Judging by analogy, we should rather expect to find slight continuous changes occurring during a long period of time, followed by a somewhat sudden transformation into a new species, or by rapid extinction. However this may be, when the stability of a mode of motion vanishes, the physicist either finds that it is replaced by a new persistent type of motion adapted to the changed conditions, or perhaps that no such transformation is possible, and that the mode of motion has become extinct. The evanescent type of animal life has often been preserved for us, fossilized in geological strata; the evanescent form of government is preserved in written records or in the customs of savage tribes; but the physicist has to pursue his investigations without such useful hints as to the past.

The results of Mendel's hybridization studies and the independent confirmatory evidence furnished by De Vries, Correns, and others all indicate the necessity of differentiating unit characters and of following separately the inheritance of each unit character. The idea which it involves of the purity of the gametes with respect to unit characters, the segregation of unit characters in the formation of the gametes, is one of fundamental importance. Such work has given a marvelous impetus to studies in inheritance. Numerous investigators have followed up this work, but it will be many years, perhaps, before a test of the Mendelian laws can be carefully made with any great number of plants and animals. The exceptional instances already reported of the appearance of mosaic characters and the dissimilarity in the product of reciprocal crosses themselves indicate further fields for experimental research. Only a word need be said bearing upon the phylogenetic side of physiological work, since phylogeny, as well as pathology or ecology, constitutes a separate section of biological science. The admirable work accomplished by De Vries, serving beyond all question to demonstrate experimentally the origin of species by leaps or mutations, necessitates laying further stress upon discontinuous variation as a factor in the origination of existing species of plants. It is to be doubted, however, that most botanists will at present concur in such an opinion as that the evidence advanced is sufficient to disregard or disparage the part which is played by continuous variation in the origination of species. Continuous variation must be manifest by relatively slight variations; and it would be unfair to expect at this time the experimental proof of its efficiency. It may even be assumed that there is a complete series between continuous variations and discontinuous variations, as well, perhaps, as between the possibilities of inheriting immediately or ultimately such variations. Many of the problems in plant physiology are distinctly practical problems. The task of the physiologist is primarily to study the activities of plants irrespective of practical bearing. To have the greatest possible breadth and force, however, the cultivated plant may not be neglected in any of its artificial environmental conditions. It is unfortunate that as yet physiological botany has not been made fundamental to agronomy, horticulture, forestry and other sciences, arts, or commercial pursuits. Physiology cannot be limited by any practical problems, nor can any sacrifices be made, but a sympathy with commercial endeavor will invigorate the work, will afford equipment and will contribute toward the common good.

ELECTRICAL NOTES.

A Berlin firm has recently patented a new system of electric burglar alarm which is adapted to be placed upon doors without difficulty or any previous preparation. The apparatus is placed upon the key, which is left in the lock on the inside of the door and any attempt to turn the key causes a bell to ring. The electric bell is mounted directly upon the apparatus and there are no wires to be laid. But if desired the bell can be placed at any desired point in the usual way. The new apparatus is designed to protect the doors of apartments or stores and can be taken off very readily in case of moving. In the usual form the device consists of a small box in hard wood containing a dry battery and having an electric bell mounted on the top. Proper contact arrangements are made so that these will be operated upon turning the key of the door. Should the battery give out, a new one can be put in by any person.

The United States Weather Bureau has made arrangements to send wireless telegraphic storm warnings to vessels at sea with weather forecasts and storm warnings. This will be done by the systematic collection, by means of wireless telegraphy, of meteorological observations from vessels far out at sea, and the immediate transmission by the same means of the forecasts and warnings to other vessels. A special code has been prepared in the Weather Bureau, by means of which exact information as to date and hour, the latitude and longitude of the vessel, the atmospheric pressure, and temperature, the force and direction of wind, and the character of the sky, is all compressed into four words. The task of deciphering this meteorological dispatch will be performed by the wireless operator aboard the vessel. Upon its receipt at any of the coast wireless telegraph stations it will be at once forwarded to Washington, having preference as government business.

Electric railroads in Europe which use alternating current for the motors are few in number at present, but it is likely that this system will come into use extensively in the future, as soon as the proper working conditions have been established. A new road which is to be equipped on the single-phase alternating current system is the Swiss line running from Locarno to Bignasco, in the southern part of the country. The contract for this road has been lately awarded by the government to the well-known Oerlikon electrical firm. The line is 40-inch gage or the standard European narrow gage, and it will have a total length of 17 miles. The steepest grades on the line are 3.3 per cent. It is proposed to run trains having a total weight of 40 tons, made up of electric locomotives and trailers. The motors are to use a high tension current, taken from the overhead trolley, at about 6,000 volts. The alternating current system was decided upon for the new line on account of the good results which were obtained with the Seebach-Wittingen electric road, which is one of the first of this kind to be installed on the Continent, and it is now running very successfully.

It has now been definitely decided to build the electric road which will ascend Mont Blanc, and the contract has been awarded to a prominent European construction firm. After considering different projects, the government decided upon the one which was presented by M. Duportal, a prominent engineer of the administration. According to it, the road is to be built in two sections. At present only the first of these sections will be built, and the second section, which goes to the summit, will be constructed later on, when the engineers will have the working data which are given by the first part of the line. The station of Fayet on the Paris, Lyons and Mediterranean Railroad is the starting point, and the road will wind up the mountain in many curves which are chosen so as to give as low a grade as possible, ending in the neighborhood of the peak known as Aiguille du Gouter at an altitude of 13,000 feet, which is the terminus of the first section, giving a distance of 11.5 miles for this part. The terminus is 1,800 feet from the summit of the mountain, which is at an altitude of 14,800 feet. Tourists who take the electric road can then climb the rest of the way without any great difficulty. Changes in temperature and barometric pressure make it necessary to mount up at a slow speed, otherwise the passengers would suffer from a too sudden change. From Fayet to the summit of Mont Blanc we find a difference of 25 deg. C., and the trains will not mount up at a higher rate than 4,000 feet per hour, seeing that 8 degrees per hour is about the highest change that the human system will stand comfortably. To reach the summit will take about four hours when the road is all completed. A rack-and-pinion system, with the rack in the middle of the track and placed on metallic ties, is to be used. Electric locomotives of 150 horse-power are to take the trains. The locomotives will weigh about 15 tons. Some 80 passengers will be carried in two cars of four tons weight, and the whole train including the load will have 35 tons weight. Eight trains will be running on the road at a time. Current is supplied from a hydro-electric plant which is to be erected near by. For the first section about 2,000 horse-power will be needed, and this will be increased to 3,000 horse-power for the two sections. According to the present project, the line is to cost about two million, including the electric station.

TRADE NOTES AND FORMULÆ.

Sensitive Reaction for the Compounds of Molybdenum.—Herren Spiegel and Maass, in Berichte, propose the following: One part of uncolored phenylhydrazine is dissolved in four parts of a 50 per cent solution of acetic acid. Five cubic centimeters of this solution are added to the liquid to be tested for molybdenum, and the mixture is boiled from one to two minutes. In case molybdenum is present a red coloration ensues. In doubtful cases the liquid, cooled to 50 deg. C., is stirred with a few drops of chloroform or acetic ether. This dissolves the coloring principle, which has become perceptible from the separation of the layers, unless the coloration of the subjacent liquid prevents the observation. The test permits of discovering the presence of 0.00001 gramme of molybdenum, and even less, in 10 cubic centimeters of this solution. The tungstates, vanadates, antimoniates, chromates, and salts of tin, manganese, and uranium, do not interfere with the test. Arsenic acid in a rather concentrated solution gives a yellowish red coloration with phenylhydrazine, but this is accompanied with separation of benzine. In dilute solution this coloration is not produced, and in any case the chloroform permits of distinguishing this reaction from that of molybdenum. It is indispensable to operate in presence of an excess of phenylhydrazine.

Manganese Ore as a Desulphurant in the Martin Basic Process.—According to Herr Reimer, in Stahl u. Eisen, opinions are divided as to the desulphuring of the metal in the Martin basic process; so, in general, a casting poor in sulphur, containing one per cent at most, is prescribed. As desulphuring agents, carbon, slag containing lime, and metallic manganese are utilized. He has developed two operations, one without and the second with addition of manganese ore, other conditions being the same. The first operation, without manganese ore, notwithstanding the addition of the refined casting and of ferro-manganese, has afforded results of less value than the second, which distinctly exhibits the desulphuring properties of the manganese ore. The latter is reduced, and it is the protoxide of manganese which impedes the combustion of the manganese and carbon. The slag containing peroxide of iron and lime acts but slightly as a desulphurant, and only with the aid of manganese and carbon. It does not remove the sulphur, but only absorbs it and abandons it again in the metallic bath, when the carbon and manganese have disappeared or have been present only in insufficient quantities. The metallic manganese, as well as the slag containing manganese protoxide, are excellent desulphurants. The crude casting containing one per cent of sulphur may be converted into a faultless substance.

Estimation of Perchlorates.—Seickmann has given a process for the determination of perchlorates in sodium nitrate by reduction by means of lead, and determination of the chlorides present before and after the production. Herr Hoenig describes in the Chemiker Zeitung the use of other metals for the same purpose. He has found that finely divided iron (*ferrum limatum*) is quite suitable. From 5 to 10 grammes of nitrate containing the perchlorate (but not more than 5 per cent) are melted in a nickel crucible. Two or three grammes of iron are introduced and mixed with a glass stirrer. A watch glass is placed on the crucible to avoid loss by projection, and the crucible is kept for half an hour, stirring from time to time, over a flame 6 centimeters in height (scarcely in contact with the base of the crucible) and heated to a very dull red. The mass is recovered with water after cooling, the solution filtered, and the chlorine in the filtrates estimated by weight. Crucibles of porcelain or of platinum are not to be employed, the first, because of their fragility, the latter because platinum is attacked by the fused nitrate. The results are satisfactory. If the proportion of perchlorate exceeds five per cent, the mixture will fuse on the addition of the divided iron. In this case it is necessary to dilute the salt to be analyzed with pure nitrate to sufficient degree before the test.

Preparation of Cantharidine.—The Japanese scientist Puran Sing publishes in the Bulletin of the Pharmaceutical Society of Japan the following method for the preparation of cantharidine: 25 grammes of pulverized cantharides are treated with a mixture of 10 cubic centimeters of nitric acid and 200 cubic centimeters of water. The mixture is evaporated to dryness on the water bath, with addition of a little gypsum before complete desiccation. The dry mass is exhausted with chloroform, and the solvent is distilled. The cantharidine then crystallizes from the yellowish oily residue. This oil is separated by washing with a small quantity of ether or alcohol. The purpose of the evaporation of the cantharides with nitric acid is to oxidize the fatty matter and thus increase the solubility and facilitate the separation of the crystals of cantharidine. Another method has been proposed by the Japanese, Nagai. Twenty-five grammes of pulverized cantharides are exhausted and acidified with chlorhydric acid by means of chloroform, in the Soxhlet apparatus. The chloroform residue, after the distillation of the solvent, deposits the greater part of the cantharidine in the form of crystals. The accompanying oil is separated out by washing with ether. The etherized solutions are evaporated, and the fatty matter contained is saponified with a little soda. The soap formed is treated with a solution of alum, which dissolves the cantharidine. By concentration of the alum solution the cantharidine is separated and united with the cantharidine crystals separated from the chloroform solution.

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